THE WEATHER AND CIRCULATION OF MARCH 1957[1]

A Month With An Extensive Polar Block and Expanded Circumpolar Vortex

HOWARD M. FRAZIER

Extended Forecast Section, U. S. Weather Bureau, Washington, D. C.

1. HIGHLIGHTS

In the previous article of this series, Woffinden [13] described the inception of a pronounced index cycle. Its initiation was associated with blocking which shifted from the Gulf of Alaska early in February to the areas of Baffin Bay and Novaya Zemlya by the latter half of the month.

During March 1957 blocking continued in the Baffin Bay-Davis Strait area, but the second area of blocking moved eastward from Novaya Zemlya to the New Siberian Islands north of Siberia. The expansion of the circumpolar vortex, which had begun in February in response to the development of the two blocking surges, reached a maximum in March.

The expanded nature of the circumpolar zonal circulation during the month was associated with important precipitation in the drought-stricken area of the south-central Great Plains of the United States as well as with a partial temperature reversal from the February pattern.

2. BLOCKING AND THE EXPANDED CIRCUMPOLAR VORTEX

BLOCKING

The 30-day 700-mb. mean chart for March (fig. 1) depicts the location of the two key blocking features of the month. The first was centered in the Davis Strait off the Labrador coast (DN center + 430 ft.) and the second over the New Siberian Islands north of northeastern Siberia (DN center + 330 ft.).

Figure 2 was prepared to trace the history of these blocks from 5-day mean charts. Height departure from normal charts for 700 mb. are prepared routinely thrice weekly for 5-day mean periods centered on Monday, Thursday, and Saturday. Figure 2 contains all 5-day mean height anomaly centers during March with departures of 100 ft. or greater and/or those which could be followed on two or more consecutive charts. The 5-day mean positive DN center (fig. 2A) associated with the block centered in the Davis Strait on a monthly basis was first observed over southern Greenland very early in the month. It then retrograded, with the track describing a more or less circular path over the Davis Strait, during the middle of the month. The remnant of an older surge, which had affected the area during the latter half of February, is portrayed by the shorter track in Baffin Bay.

The Siberian block showed a more complex makeup from a 5-day mean standpoint. Figure 2A shows this block as the product of three 5-day mean surges. The first impulse, centered near 72° N., 150° E., before the month began, spread its influence over the polar region during the first half of the month and then dropped southward to Scandinavia during the latter half. The second surge is the short two-position track along the 70th parallel between 120° and 135° E. The third blocking wave is represented by the track beginning in the central Pacific at mid-month. It moved northwestward and com-

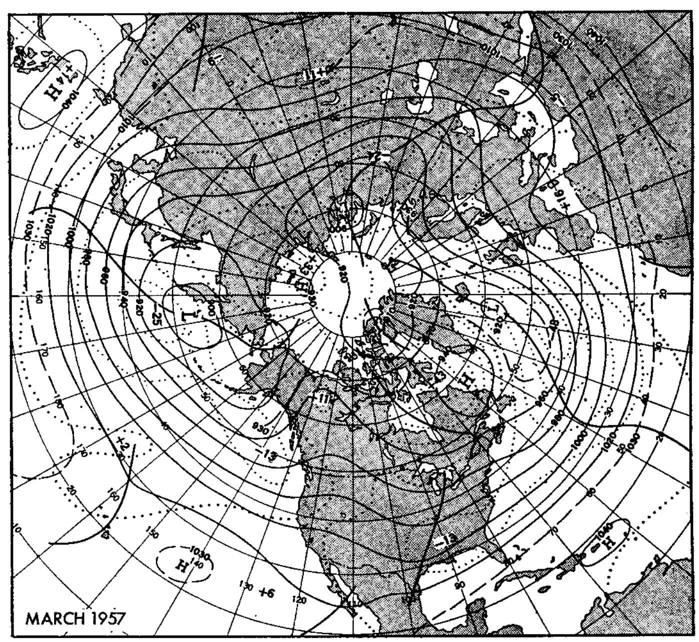


FIGURE 1.—Mean 700-mb. contours (solid) and departures from normal (dotted) (both in tens of feet) for March 1957. The expanded nature of the circumpolar vortex is indicated by the extensive area of positive anomaly at higher latitudes and negative anomaly in the middle latitudes, as well as by weak and suppressed subtropical Highs.

[1] See Charts I–XVII, following p. 112 for analyzed climatological data for the month.

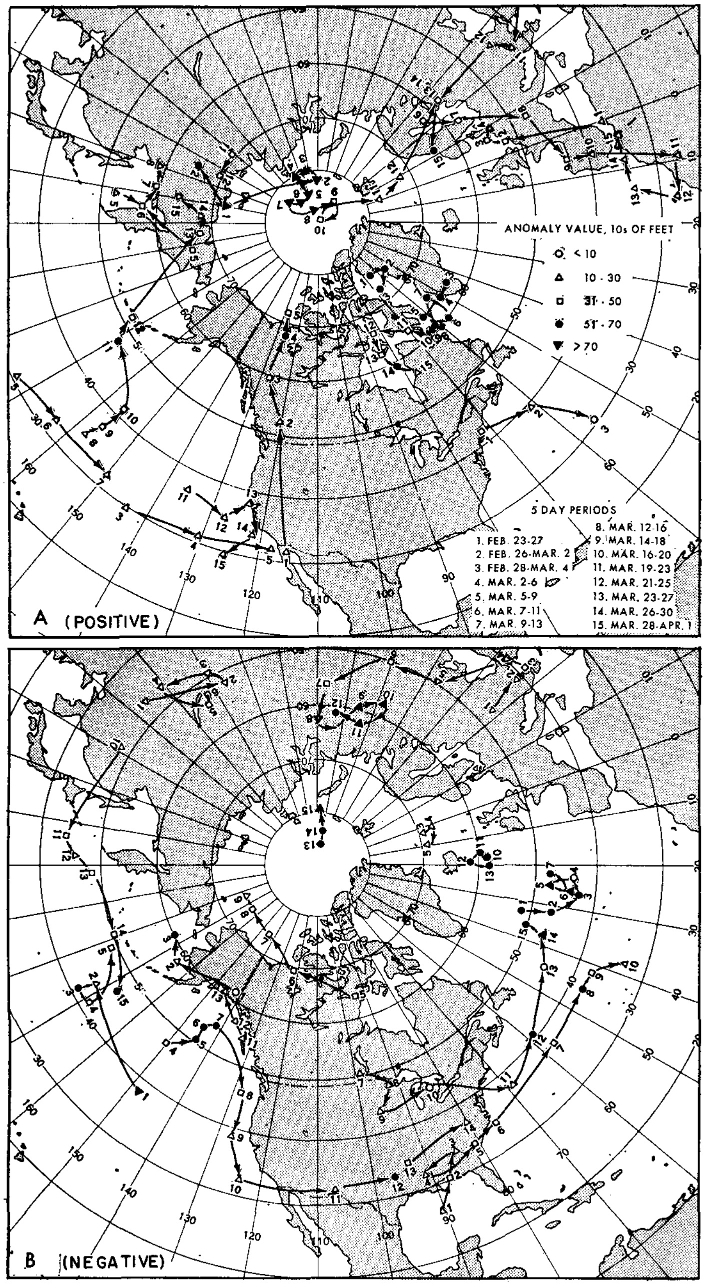


FIGURE 2.—Tracks of 5-day mean 700-mb. height anomalies: (A) positive centers, (B) negative centers. The plotting code for both charts is found on A. Retrograde motion of the anomaly centers at high latitude was a feature. Note also the tendency of middle-latitude centers to show meridional and/or retrograde motion, while lower-latitude centers displayed eastward motion.

bined with the second surge over northeastern Siberia during the fourth week of the month.

The magnitude of the two monthly mean DN centers in figure 1 is not particularly great, but two facts important to the hemispheric circulation for March should be pointed out. First, positive departures from normal in the mid-troposphere were observed over practically all of the area north of 60° N. Secondly, the 700-mb. chart for the 30-day period from mid-February to mid-March (fig. 3) is more representative than is figure 1 of this extensive polar block at its peak intensity. The DN field for this period (fig. 3) shows the magnitude of the height anomalies at 700 mb. to be + 650 ft. in the Davis Strait area and + 620 ft. north of Siberia. Visual inspection of a 25-year file of monthly mean charts reveals very few months with an extensive and intense polar block comparable to that depicted in figure 3. Some months in recent years which have exhibited this type of block have been discussed by Winston [11, 12] and Klein [3] in previous articles of this series.

Manifestations of the extensive polar block in the mean circulation for the month are shown in the various figures accompanying this article. The primary feature was a deceleration of the high-latitude westerlies compensated by an increase in the lower-latitude westerlies, or an expansion of the entire circumpolar vortex.

THE EXPANDED CIRCUMPOLAR VORTEX

The monthly mean circulation of March 1957 (fig. 1) exhibited most of the classical characteristics of the low-index pattern as described by Willett [10], Namias [6, 7], and numerous others [3, 11, 12].

Table 1 and figures 4, 5, and 6 reflect typical features of an expanded circumpolar vortex. Table 1 details the above normal value of the sea level polar easterlies and the greater than normal speed of the 700-mb. subtropical westerlies. The remaining indices listed in table 1 show below normal values for the month.

Figure 4, a representation of the 700-mb. 30-day mean zonal wind profile, depicts stronger than normal westerlies south of 47° N. and less than normal values to the north. Namias [6, 7] has shown that the total momentum of the mid-tropospheric westerlies, averaged over all latitudes, generally reaches a certain value for a particular month, and it is only the distribution of momentum with latitude which varies. This tendency for the total momentum of the westerlies to be conserved is illustrated quite clearly in figure 4.

Figure 5, a profile of the sea level pressure for the month, portrays the greater than normal concentration of mass at high latitudes. This in turn was compensated by a deficit of mass at middle and lower latitudes. A similar effect was noticeable at 700 mb. (fig. 1), where the positive anomalies north of 60° were surrounded by an almost continuous ring of negative departures from normal at middle latitudes.

TABLE 1.—*Monthly mean index values (m. p. s.) in the Western Hemisphere during March 1957*

Index	Level	Observed	Normal	Departure from normal
Polar easterlies 55° N.-70° N.	Sea level	4.2	2.0	+2.2
Zonal westerlies 35° N.-55° N.	Sea level	2.3	2.8	−0.5
Subtropical easterlies 20° N.-35° N.	Sea level	−0.7	0.9	−1.6
Polar westerlies 55° N.-70° N.	700 mb.	1.1	2.9	−1.8
Zonal westerlies 35° N.-55° N.	700 mb.	8.4	9.1	−0.7
Subtropical westerlies 20° N.-35° N.	700 mb.	9.2	7.5	+1.7

Perhaps the most striking aspect of the expanded nature of the circumpolar vortex is provided in figure 6. The mean position of the primary belt of maximum wind speeds in the mid-troposphere was south of normal over the entire Northern Hemisphere. Several investigators (for example [4] and [8]) have noted a tendency for the low-index state to be limited to one portion of the hemisphere. This has been attributed to a shift in the circulation pole from its normal position near the geographic pole to the side of the hemisphere exhibiting low-index characteristics. This asymmetry then results in high index over the opposite portion of the hemisphere. This tendency is usually associated with a single high-latitude block, but during February-March 1957 a double block was present. The dual nature of this block and the extensive polar area it influenced permitted the circumpolar vortex to expand over the entire hemisphere, although the more persistent nature of the Davis Strait block made the effect most pronounced over North America and the Atlantic Ocean.

The index cycle of February-March may be viewed in broad terms by reviewing the highlights of the general circulation during the past 10 months. Climatologically the expansion and contraction of the circumpolar vortex undergoes an annual cycle. Klein has illustrated the annual north-south march of the 700-mb. jet stream, computed from normal monthly 700-mb. maps on a hemispheric basis, in a recent U. S. Weather Bureau Research Paper [2]. His jet axis has been reproduced as a dashed curve in figure 7, but only for the area from 0° westward to 180° for easy comparison with graphs prepared routinely in extended forecasting work. Figure 7 (dashed) depicts 49° N. as the northernmost latitude reached by the normal jet stream on a monthly mean basis, and this occurs in late August and early September. The normal minimum latitude of 38° N. is reached in late February and early March.

The latitude of the 30-day mean primary jet stream at 700-mb. on observed monthly mean maps for the 10 months ending with the period mid-March to mid-April 1957 is plotted as a solid curve in figure 7. Of interest is the fact that the observed curve lags the normal by about 2 months during the summer and fall of 1956. The resulting southward displacement of the westerlies during July, August, and September may have been associated with the mildness of hurricane activity during the 1956 season [1], and the compensating northward shift of the mid-tropospheric west wind maximum during October, November, and December. During the first three months of 1957 the jet stream was again displaced south of normal, while the time lag between the observed and normal curve apparently continued, but with less time gap. Of particular interest in regard to March 1957 is the pronounced dip in the solid curve which begins in February and reaches a minimum point (for the winter season) during the third week in March. At this time the jet was found at an average latitude of 34° N. over the Western Hemisphere and was some 4° south of its normal minimum latitude.

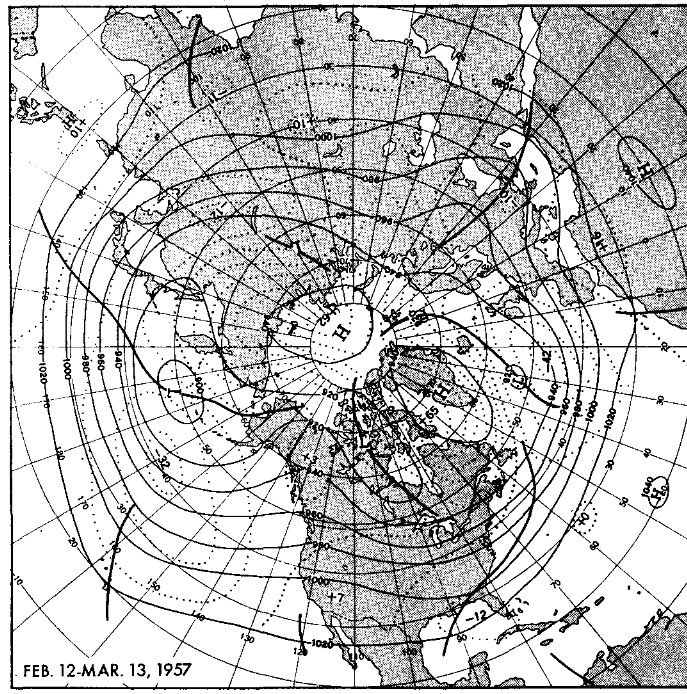


FIGURE 3.—Mean 700-mb. contours (solid) and departures from normal (dotted) (both in tens of feet) for mid-February to mid-March 1957. Blocking over polar latitudes, which was characteristic of February and March, reached its peak intensity during this period.

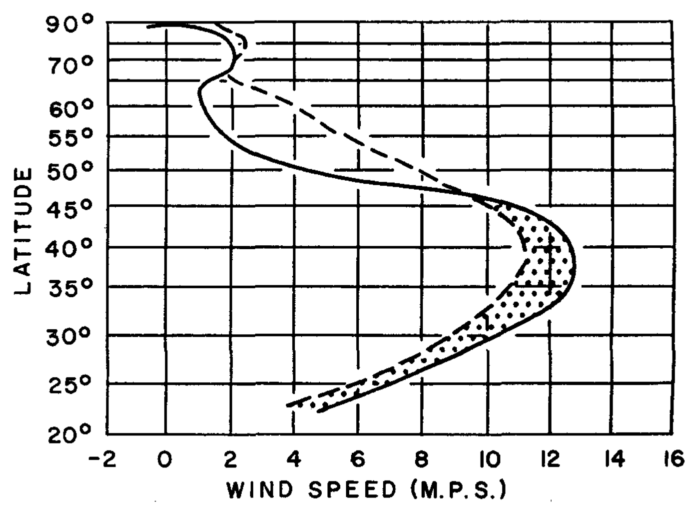


FIGURE 4.—Mean 700-mb. zonal wind speed profile for the Western Hemisphere for March 1957. The dashed curve represents the normal and the solid curve the actual profile for the month. Note how the decrease in speed of upper-latitude westerlies was compensated by an increase in speed in lower latitudes, therefore tending to conserve total momentum of the westerlies.

3. MONTHLY MEAN CIRCULATION AND WEATHER ANOMALIES IN THE UNITED STATES

The anomalies of temperature and precipitation observed over the United States during March were closely related to the development of a new monthly mean trough

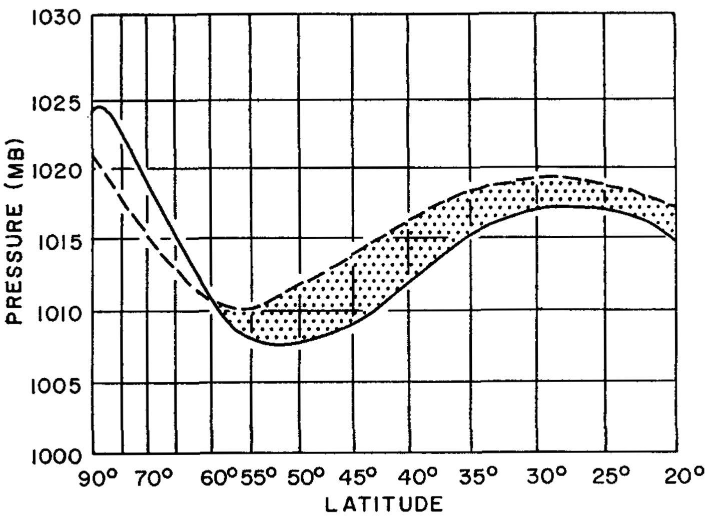


Figure 5.—Mean sea level pressure profile for the Western Hemisphere for March 1957, with normal profile dashed. Excess of mass north of 60° was offset by deficit to the south.

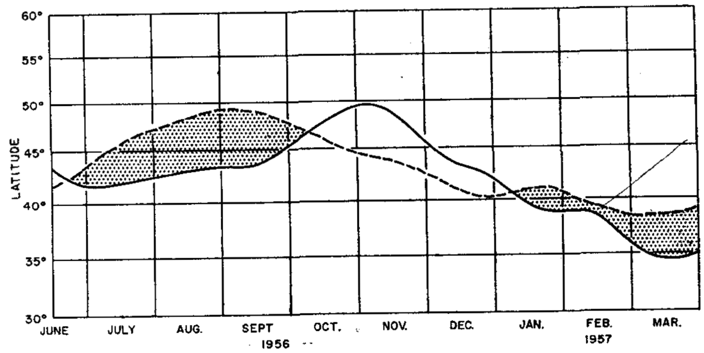


Figure 7.—Latitude of 700-mb. monthly mean maximum wind speeds for the Western Hemisphere. Dashed curve represents the normal latitude of the primary jet stream at this level. The actual curve (solid) was plotted from 30-day mean data prepared twice a month. Note the southward displacement of the 700-mb. jet stream during the summer of 1956 and the first three months of 1957. Note also how the observed curve lags the normal in reaching annual maximum and minimum latitude points.

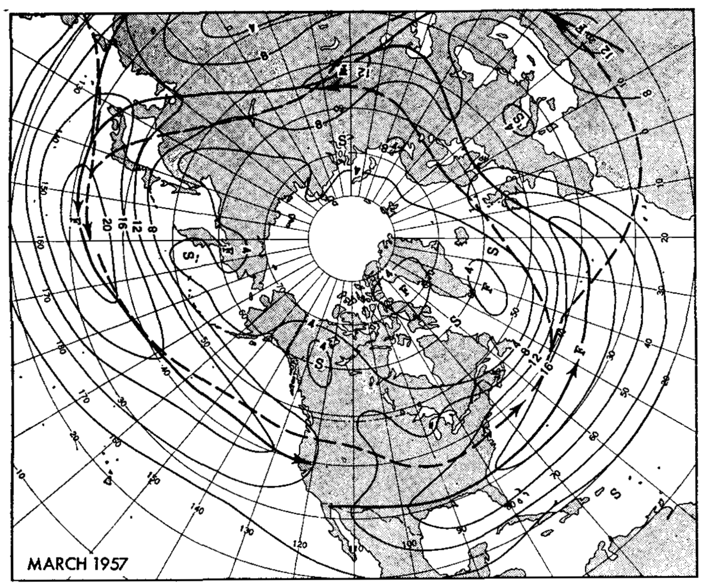


Figure 6.—Mean 700-mb. wind speeds (isotachs drawn at interval of 4 m. p. s.) for March 1957. Heavy dashed lines delineate normal position, heavy solid lines actual position, of primary jet stream at this level. "F" refers to areas of fast wind speeds; "S" to areas of slow winds. The primary jet stream during March was south of normal over the entire hemisphere.

observed in the center of the country (fig. 1). Perhaps the presence of the block in Davis Strait and an expanding half-wavelength between the Atlantic trough and the west coast ridge favored this development, although the physical mechanism involved is obscure. Rapid deepening occurred in conjunction with the formation of this new trough shortly after the middle of the month. This deepening was associated with heavy precipitation over the south-central Great Plains during the latter half of the month, especially during the week ending on the 24th (fig. 11c).

PRECIPITATION

Chart II depicts precipitation totals for March over the United States, while Chart III outlines the anomalous character of these totals. Table 2 also sheds light on the anomalous features of the precipitation, showing this to have been the wettest March of record at two stations in the Pacific Northwest. Examination of the daily totals to determine the distribution of the precipitation reveals that it was rather evenly spaced throughout the month, indicating a relationship between the broadscale features of the circulation and the precipitation. Figure 1 shows westerly flow in both a contour and an anomalous sense over the Northwest and implies an association between stronger than normal maritime flow and the heavy precipitation observed during the month.

Table 2 also lists the month as the wettest March in the 72 years of record at Houston, Tex. The Gulf Coast area in general, including the interior sections of eastern Texas, received generous amounts of rainfall. This precipitation can be associated with the low-index character of the monthly circulation and the allied increase of cyclonic activity in the lower middle latitudes. Daily storm tracks (Chart X) were well south of Klein's [2] primary tracks for the month. The 30-day maximum wind speed belt at 700 mb., as shown in figure 6, was also south of normal and lay directly over the Gulf coast. The center of negative height anomaly over this area on the 700-mb. monthly mean map (fig. 1) was also associated with the heavy precipitation observed.

Light precipitation occurred over the Northern Plains, through the Ohio Valley, and also over much of New England. Fargo, N. Dak., reported the month as the driest March in over half a century (table 2). The monthly mean chart (fig. 1) shows that the Northern Plains were under the influence of northwesterly flow at 700 mb. This, coupled with the shift of the primary storm track well to the south of normal, helps account for the deficiency of precipitation noted in the area.

Subnormal amounts over New England can also be associated with the southward displacement of the storm tracks during the month. In addition, the northerly and northeasterly DN flow suggested in figure 1 probably cut off the source of moisture supply for this region.

Easterly DN flow over the Ohio Valley, coupled with faster than normal westerlies along the Gulf coast, also operated to cut off the Gulf of Mexico as a source of moisture. Lack of moisture must have been the compelling factor in the case of the Ohio Valley because Chart X shows several storm tracks during the month passing through and to the south of the area. Although figure 1 depicts the area in the normally favored region (for heavy precipitation) just ahead of the mean trough, it shows that the amplitude of the wave and the southerly flow east of the trough were very small.

TEMPERATURE

Monthly average temperature anomalies at 74 out of 100 selected stations in the country (Chart I) were one class or more colder in March than they were in February. On the same departure from normal basis, the sharpest reversal in temperature pattern took place in the area from Arkansas eastward through Georgia. In fact, a number of stations in the southeastern section of the country reversed the seasonal clock temporarily and reported monthly average temperatures for March below those observed this February.

The relationship between the monthly mean circulation features and the temperature anomalies as portrayed in Chart I–B is reasonably straightforward. In general, there was a great similarity in the patterns of temperature anomaly and 700-mb height departure from normal (fig. 1). Martin and Leight found moderately good correlations between these two variables [5]. Below normal temperatures over the Southeast correspond well to the below normal heights observed in this area, while warmer than normal readings over New England were associated with above normal heights at 700 mb. over the extreme northern section (fig. 1). In addition, easterly DN flow in this area (less than normal westerly flow) lessened the continental effect usually associated with cold weather in winter over the Northeast. The direct relationship between surface temperature anomalies and 700-mb. height anomalies did not hold up quite as well over the western third of the country, but here again there was a striking similarity in pattern.

TABLE 2.—*Selected precipitation records established during March 1957*

City	Length of record (yrs.)	Total (inches)	Anomaly (inches)	Record established
Medford, Oreg	46	5.54	+4.02	Wettest March of record.
Yakima, Wash	48	2.63	+2.17	" " " "
Dodge City, Kans	83	4.71	+3.56	" " " "
Houston, Tex	72	11.42	+8.64	" " " "
Glasgow, Mont	42	0.05	−0.55	2d driest March on record.
Fargo, N. Dak	76	0.08	−0.81	Driest March since 1895.
Parkersburg, W. Va	68	1.15	−2.39	Driest March since 1910.

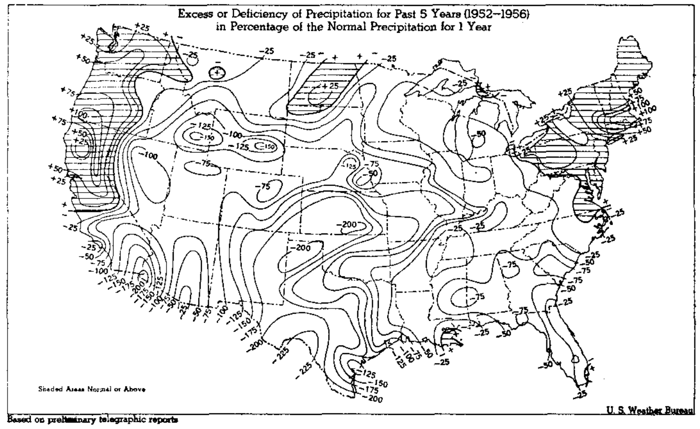


FIGURE 8.—Excess or deficiency of precipitation for past 5 years (1952–56) in percentage of the normal precipitation for 1 year. (From [9]).

4. FIVE-DAY MEAN CIRCULATION AND PRECIPITATION IN THE DROUGHT AREA

In an economic sense perhaps the most significant weather of the month was the substantial precipitation which fell in the south-central Plains—more than twice normal in many areas. The prolonged drought in this area is depicted in figure 8, while the many ramifications associated with the condition are discussed in [9].

Low-level advection of moisture from the Gulf of Mexico, as indicated by the monthly mean sea level flow shown on Chart XI, was a prime factor responsible for the precipitation which fell in the central and southern Plains region. In addition, southward displacement of the primary jet stream (fig. 6) and cyclone track (Chart X) contributed to the drought relief.

The shorter-period aspects of this precipitation, as well as other interesting weather features of the month, can be seen in the following week-to-week résumé of the 5-day mean circulation. The 5-day mean 700-mb. charts (figs. 9–12) used in this series are centered on Thursday of the weekly period and are representative of the broadscale phenomena producing the anomalies depicted on the companion charts.

WEEK ENDING MARCH 10

Above normal temperatures dominated much of the country during the week ending March 3. The northwesterly flow shown in figure 9a was effective during this first full week of the month in sweeping cooler air into most of the eastern two-thirds of the country. Above normal heights at 700 mb., combined with a favorable DN flow, produced warmer than normal temperatures over much of the West and also over northern

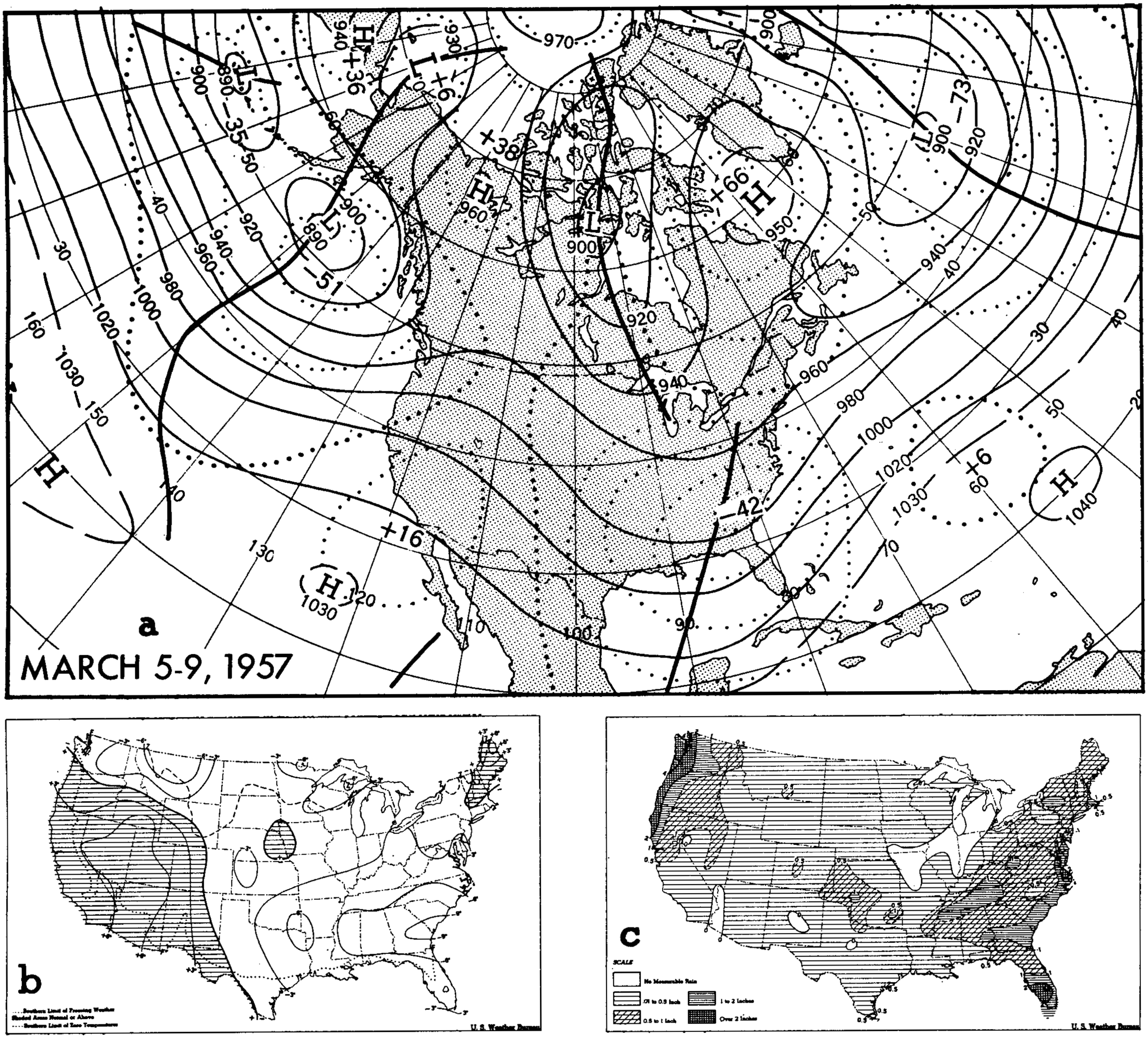


FIGURE 9.—First week of March 1957. (a) 5-day mean 700-mb. contours and departures from normal (both in tens of feet), (b) Surface temperature departure from normal, and (c) Total precipitation. (b) and (c) from *Weekly Weather and Crop Bulletin, National Summary*, vol. XLIV, No. 10, Mar. 11, 1957.

New England (fig. 9b.) The deep trough (−420 ft. DN) over the Southeast produced moderate to heavy precipitation, as did the southwesterly DN flow over the Pacific Northwest (fig. 9c). The precipitation in the Oklahoma-Kansas area occurred largely on the 4th-5th, when the trough over the Southeast was centered over the Arkansas-Louisiana area with sharp cyclonic curvature to the west. Figure 2B outlines the looping track (beginning in Gulf of Mexico) of the negative 5-day mean height anomaly associated with this trough.

WEEK ENDING MARCH 17

Rapid eastward progression of the trough-ridge system over the United States took place during this week, so that a complete reversal from the previous week was evident in both the 700-mb. features and the surface temperature anomalies. Warm air surging northward toward the Great Lakes set a number of new daily maximum temperature records on the 13th and 14th (table 3). This warm air was in advance of the only cyclonic center during the month which was able to maintain its identity

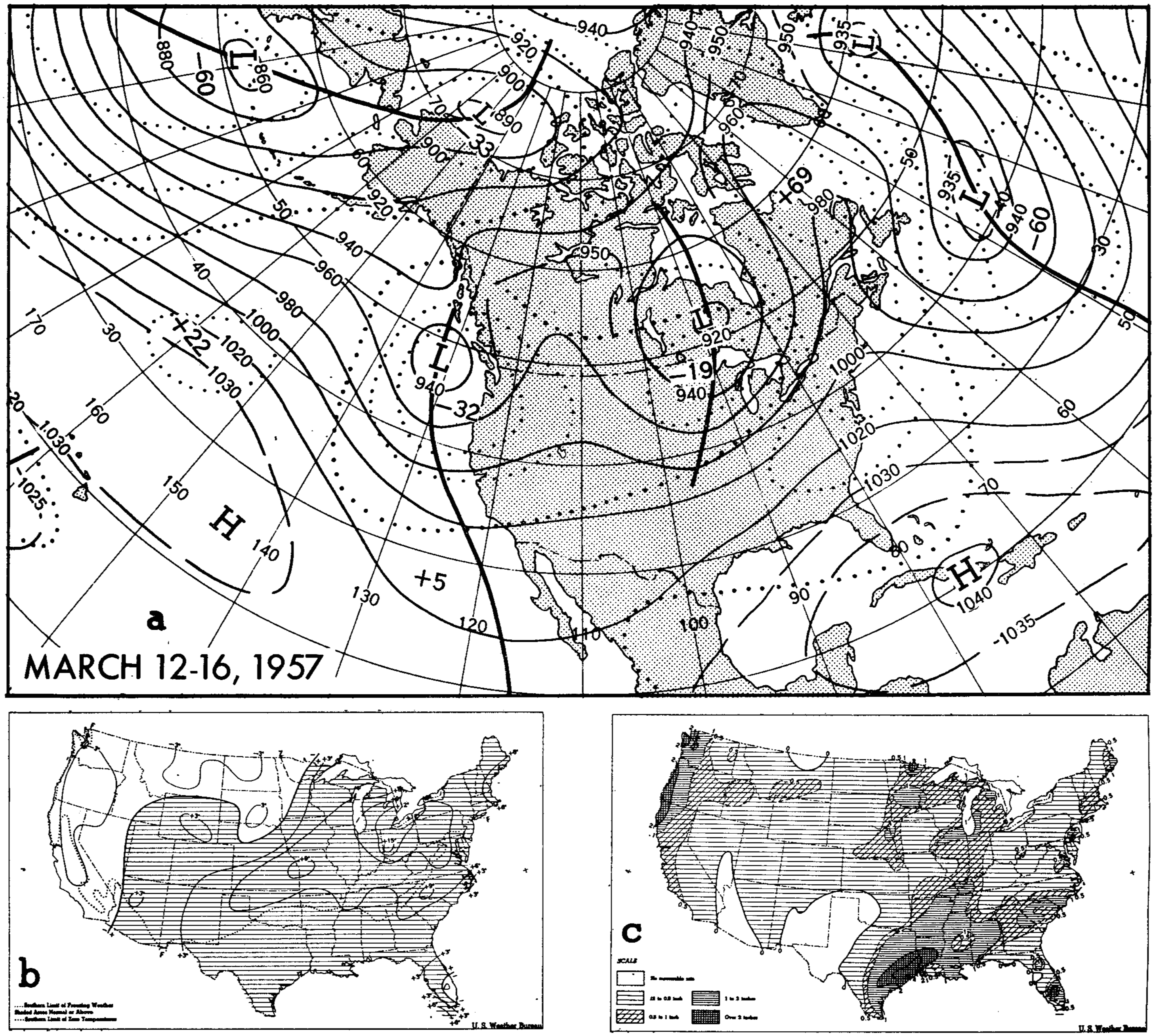


FIGURE 10.—Second week of March 1957. (a) 5-day mean 700-mb. contours and departures from normal, (b) Surface temperature departure from normal, and (c) Total precipitation. (b) and (c) from *Weekly Weather and Crop Bulletin, National Summary,* vol. XLIV, No. 11, Mar. 18, 1957.

TABLE 3.—*Selected stations at which new daily maximum temperature records for so early in the year were established during March 1957*

Place	Date	Temperature (° F.)	Length of record (yrs.)
International Falls, Minn	Mar. 11	52	18
Muskegon, Mich	Mar. 14	69	16
Detroit, Mich	Mar. 13	71	87
Buffalo, N. Y	Mar. 14	75	84

across the entire continent (Chart X). Precipitation was insignificant or non-existent in the south-central Plains during this period (fig. 10b), as the westerly flow at 700 mb. produced a characteristic rain-shadow effect, and the mean sea level pattern (not shown) produced anticyclonic curvature over the area.

WEEK ENDING MARCH 24

Heavy precipitation fell over most of the central and

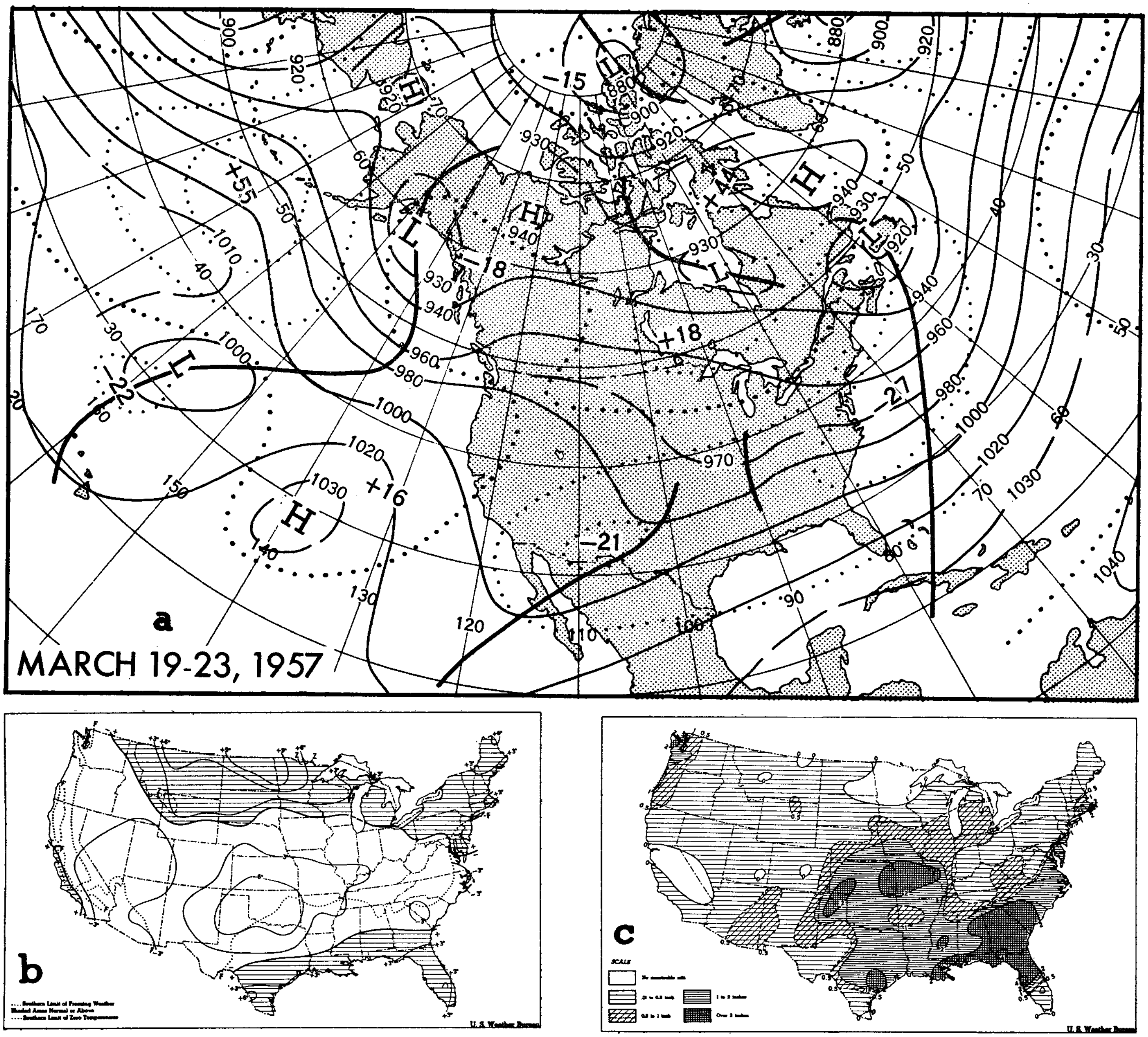


FIGURE 11.—Third week of March 1957. (a) 5-day mean 700-mb. contours and departures from normal, (b) Surface temperature departure from normal, and (c) Total precipitation. (b) and (c) from *Weekly Weather and Crop Bulletin, National Summary,* vol. XLIV, No. 12, Mar. 25, 1957.

southern Plains during this period. The daily system with which much of the precipitation was associated is discussed in detail by McQueen and Loopstra on pages 99–111 of this issue.

Figure 11a shows the 700-mb. 5-day mean chart for March 19–23. The corresponding sea level 5-day mean (not shown) depicts a Low centered just to the west of Brownsville, Tex., with a southerly flow off the Gulf of Mexico curving cyclonically through the Oklahoma-Kansas region. In the 5-day mean sense the precipitation in the southern and central Plains can then be attributed to an abundant supply of moisture in the lower levels, together with mid-tropospheric convergence associated with the 700-mb. 5-day mean trough directly over the area. The long term continuity of the negative 5-day mean height anomaly center associated with the 700-mb. trough is traced on figure 2B. This center first appeared near 47° N., 150° W. on the 5-day mean for March 2–6. The meridional track of the center in middle latitudes, and its rapid eastward motion after it dropped into the belt of faster than normal

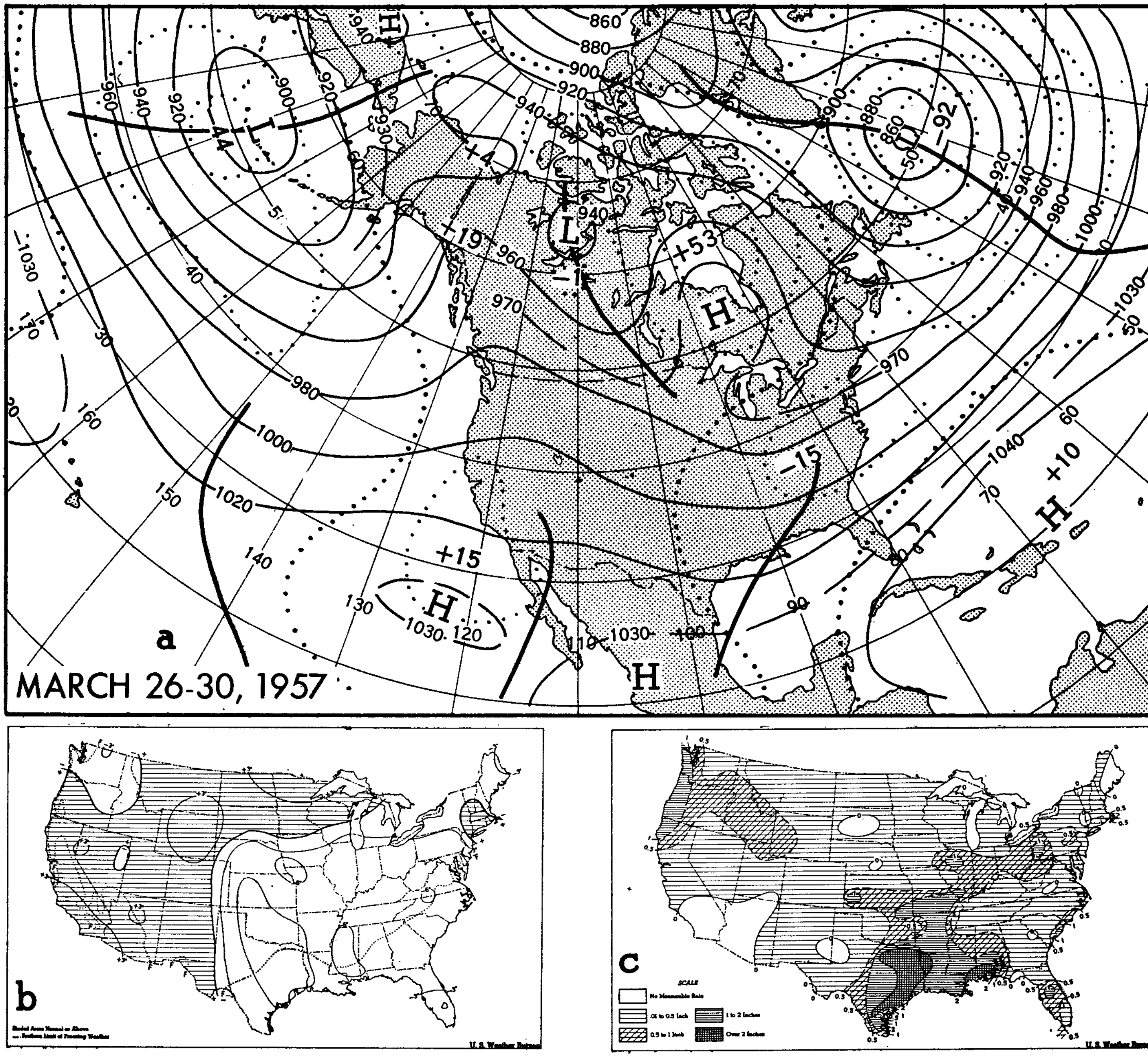


FIGURE 12.—Fourth week of March 1957. (a) 5-day mean 700-mb. contours and departures from normal, (b) Surface temperature departure from normal, and (c) Total precipitation. (b) and (c) from *Weekly Weather and Crop Bulletin, National Summary,* vol. XLIV, No. 13, Apr. 1, 1957.

subtropical westerlies, were associated with the low-index, expanded-circumpolar-vortex character of the monthly mean circulation.

A comparison of figures 10a-b and 11a-b shows the second weekly reversal in surface temperature anomalies and 700-mb. ridge-trough systems.

WEEK ENDING MARCH 31ST

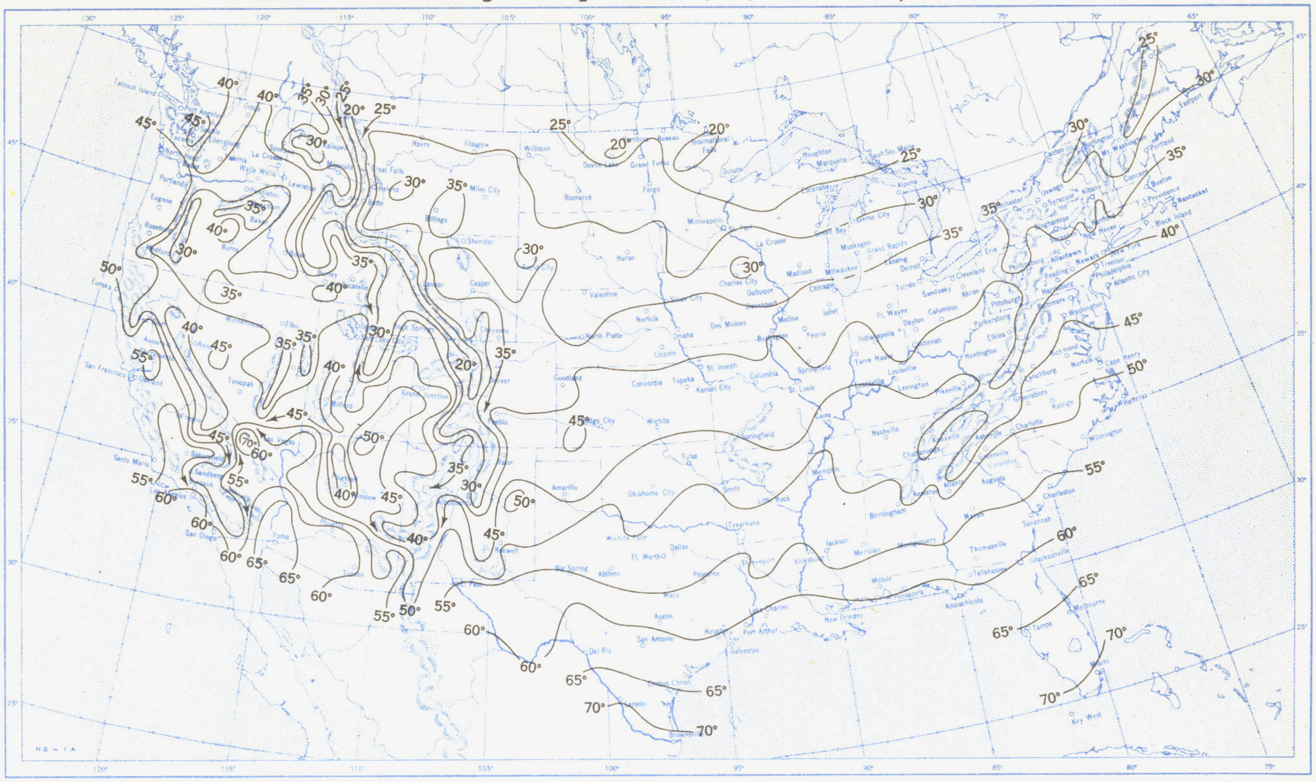
Rapid eastward motion of the mean 700-mb. features continued over the southern half of the country during the final week of March (fig. 12a). Surface temperatures reversed the anomaly of the previous week in the western third of the nation as ridge conditions became established over the area.

Precipitation continued in the Kansas-Oklahoma area, but total amounts were considerably less than during the previous week. The 5-day mean sea level chart corresponding to figure 12a continued to depict a mean southerly flow from Texas northward to Kansas, but the eastward motion of the 700-mb. trough removed an essential mechanism for the extraction of a maximum amount of precipitation from this flow.

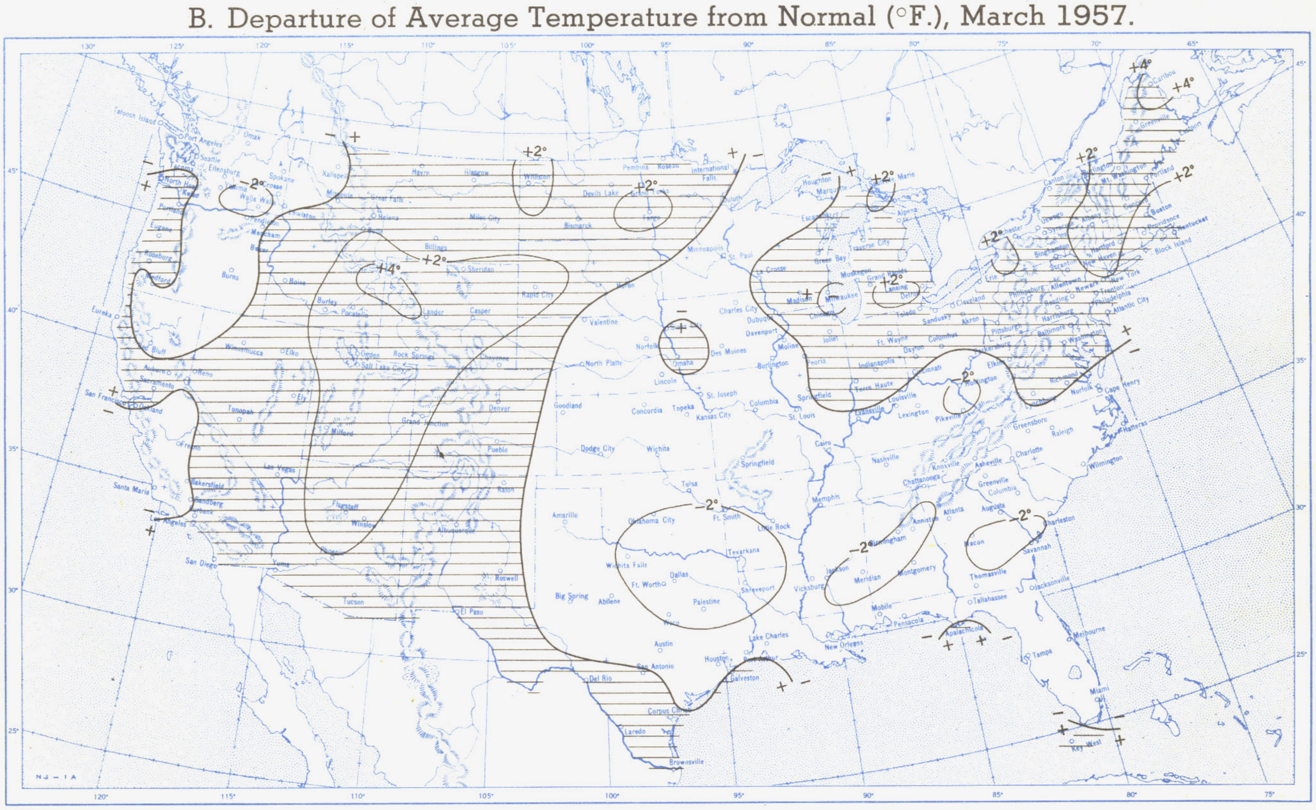
REFERENCES

1. G. E. Dunn, W. R. Davis and P. L. Moore, "Hurricane Season of 1956," *Monthly Weather Review*, vol. 84, No. 12, Dec. 1956, pp. 436–443.
2. W. H. Klein, "Principal Tracks and Mean Frequencies of Cyclones and Anticyclones in the Northern Hemisphere," U. S. Weather Bureau *Research Paper* No. 40, (In press).
3. W. H. Klein, "The Weather and Circulation of January 1956—A Month with a Record Low Index," *Monthly Weather Review*, vol. 84, No. 1, Jan. 1956, pp. 25–34.
4. N. E. LaSeur, "On the Asymmetry of the Middle-Latitude Circumpolar Current," *Journal of Meteorology*, vol. 11, No. 1, Feb. 1954, pp. 43–57.
5. D. E. Martin, W. G. Leight, "Objective Temperature Estimates from Mean Circulation Patterns," *Monthly Weather Review*, vol. 77, No. 10, Oct. 1949, pp. 275–283.
6. J. Namias, "The Index Cycle and Its Role in the General Circulation," *Journal of Meteorology*, vol. 7, No. 2, Apr. 1950, pp. 130–139.
7. J. Namias, "Thirty-Day Forecasting: A Review of a Ten-Year Experiment," *Meteorological Monographs*, vol. 2, No. 6, American Meteorological Society, July 1953. (See pp. 19–27, and 34–37.)
8. H. Riehl, et al., "Forecasting in Middle Latitudes," *Meteorological Monographs*, vol. 1, No. 5, American Meteorological Society, June 1952. (See pp. 8–11.)
9. U. S. Weather Bureau, *Weekly Weather and Crop Bulletin, National Summary*, Special Weather Summary, Drought, vol. XLIV, No. 1A, Jan. 10, 1957.
10. H. C. Willett, "Patterns of World Weather Changes," *Transactions of the American Geophysical Union*, vol. 29, No. 6, Dec. 1948, pp. 803–809.
11. J. S. Winston, "The Weather and Circulation of February 1952—A Month with a Pronounced Index Cycle," *Monthly Weather Review*, vol. 80, No. 2, Feb. 1952, pp. 26–30.
12. J. S. Winston, "The Weather and Circulation of March 1951," *Monthly Weather Review*, vol. 79, No. 3, Mar. 1951, pp. 50–54.
13. C. M. Woffinden, "The Weather and Circulation of February 1957—Another February with a Pronounced Index Cycle and Temperature Reversal over the United States," *Monthly Weather Review*, vol. 85, No. 2, Feb. 1957, pp. 53–61.

Chart I. A. Average Temperature (°F.) at Surface, March 1957.

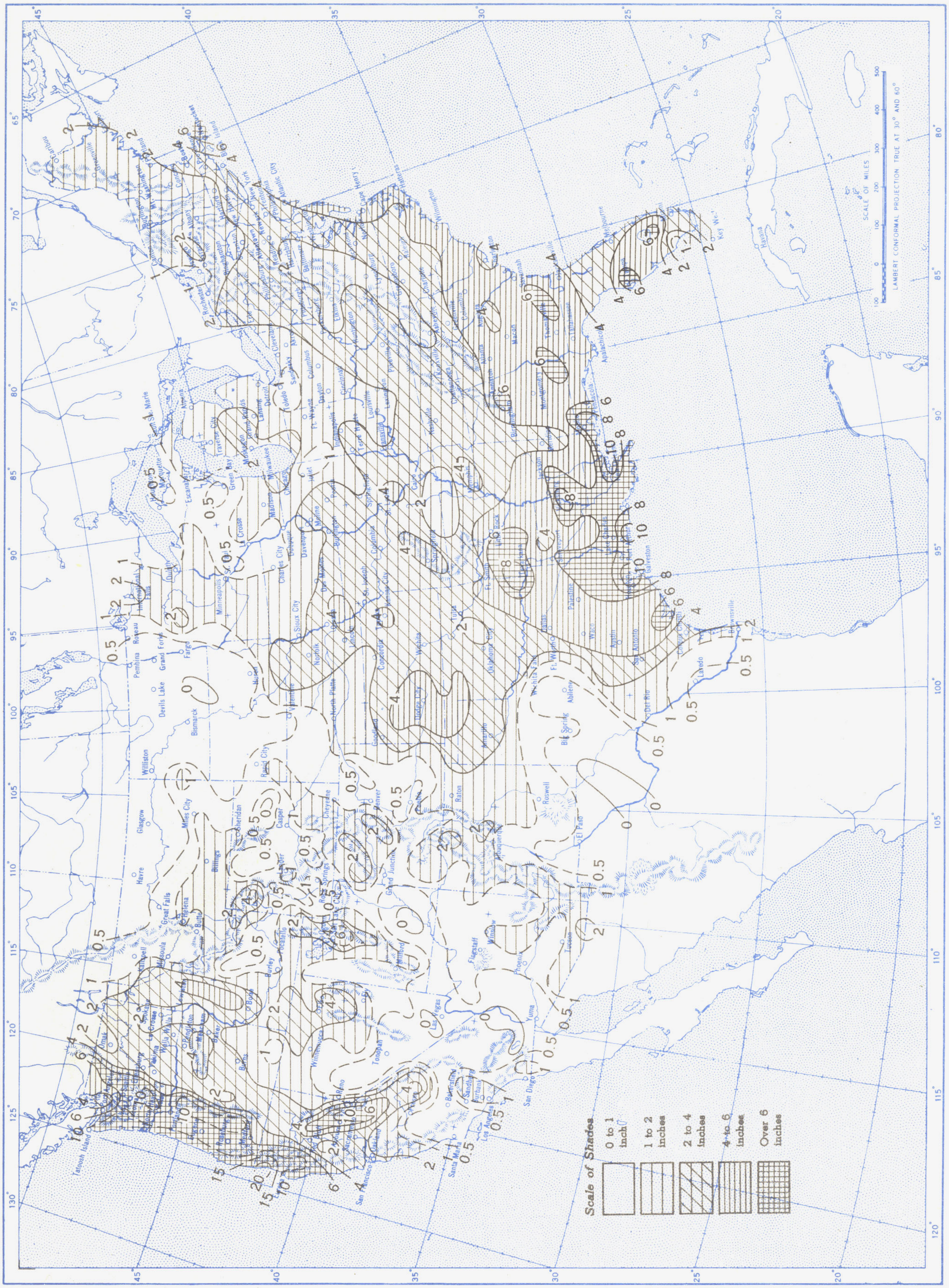


B. Departure of Average Temperature from Normal (°F.), March 1957.



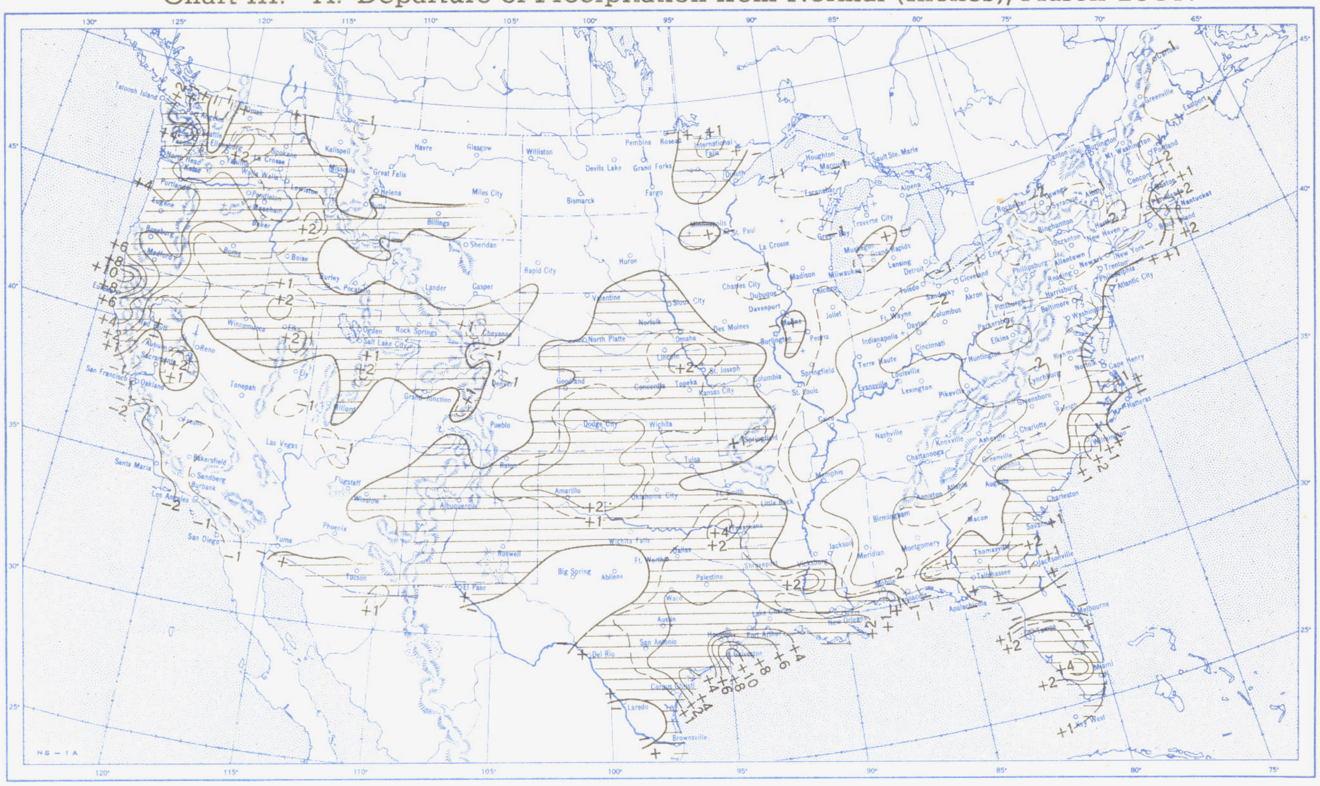
A. Based on reports from over 900 Weather Bureau and cooperative stations. The monthly average is half the sum of the monthly average maximum and monthly average minimum, which are the average of the daily maxima and daily minima, respectively. B. Departures from normal are based on the 30-yr. normals (1921-50) for Weather Bureau stations and on means of 25 years or more (mostly 1931-55) for cooperative stations.

Chart II. Total Precipitation (Inches), March 1957.

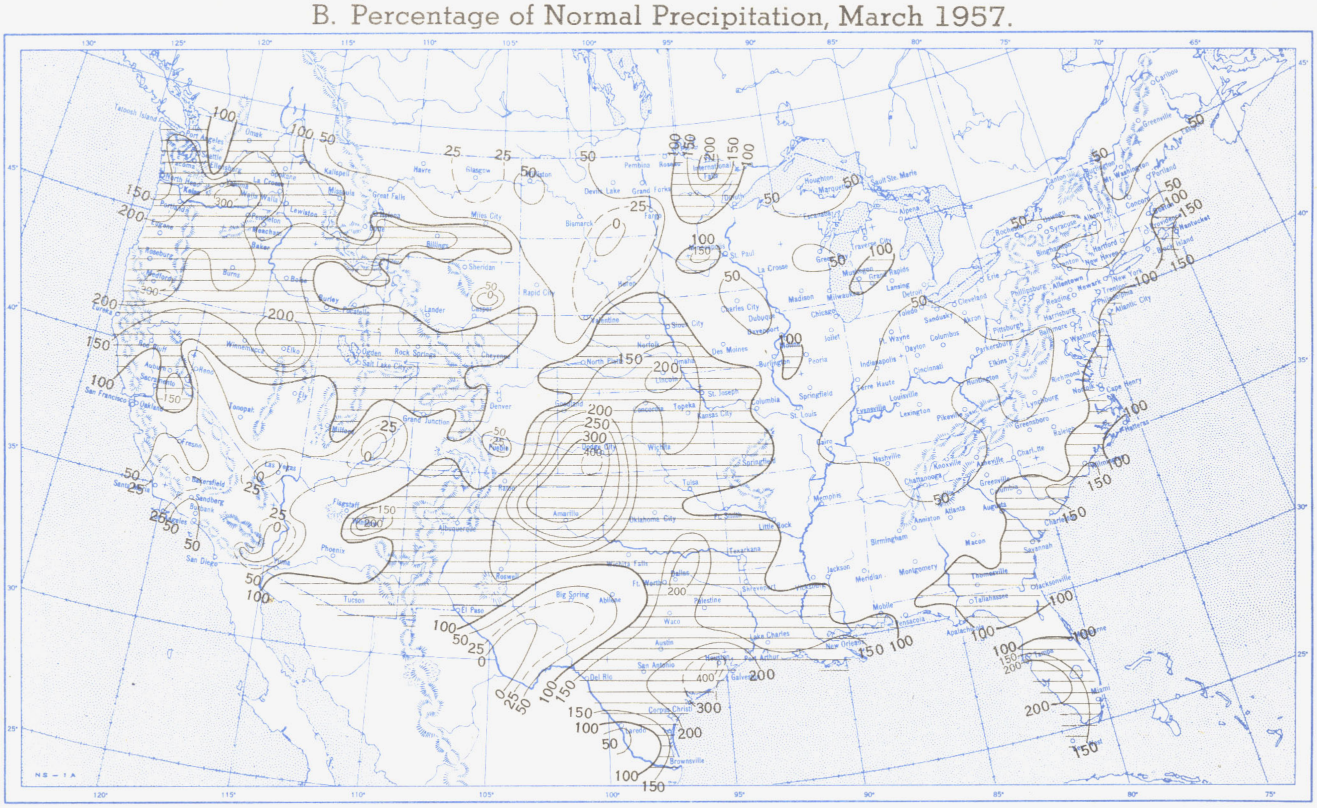


Based on daily precipitation records at about 800 Weather Bureau and cooperative stations.

Chart III. A. Departure of Precipitation from Normal (Inches), March 1957.

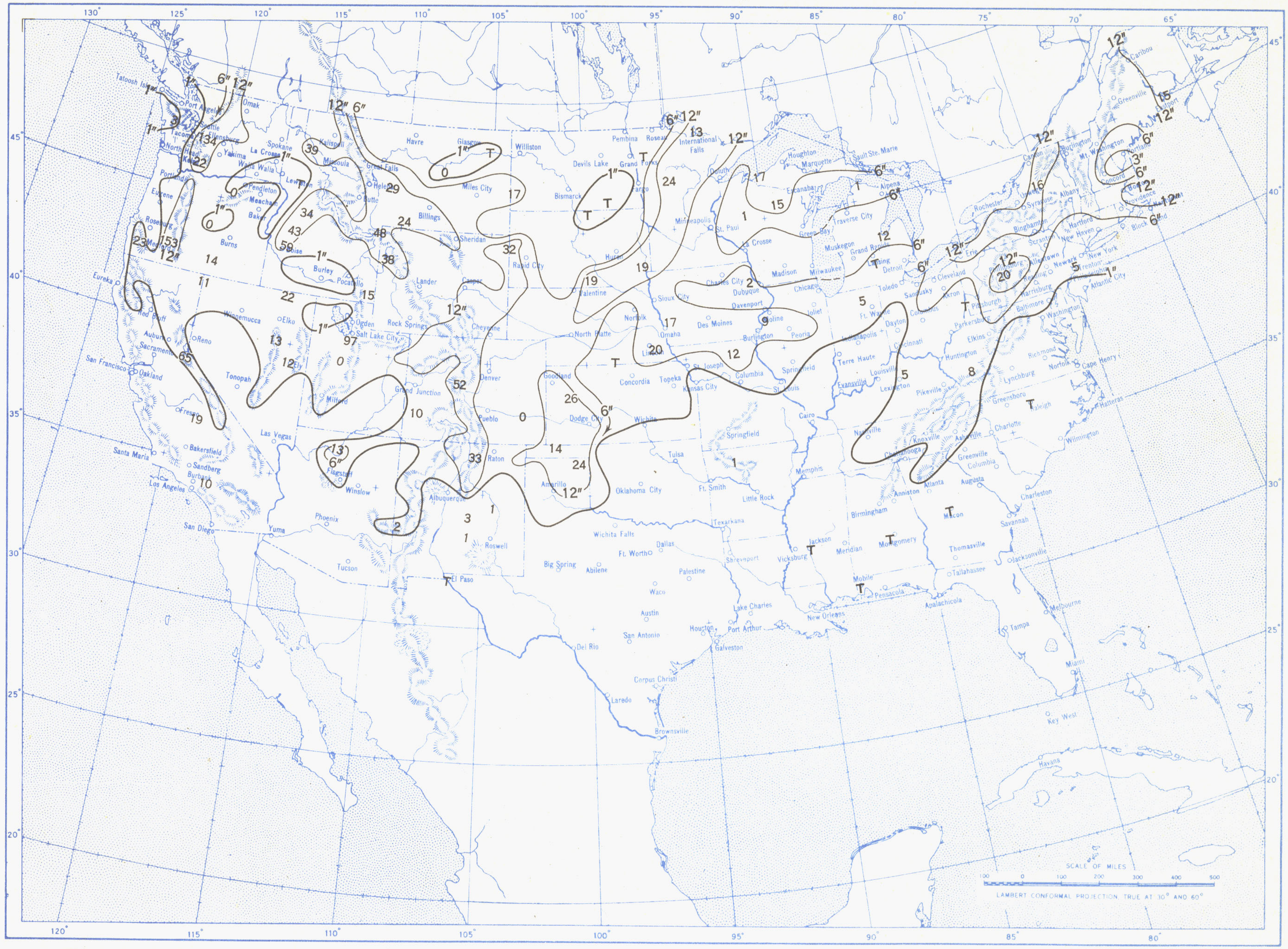


B. Percentage of Normal Precipitation, March 1957.



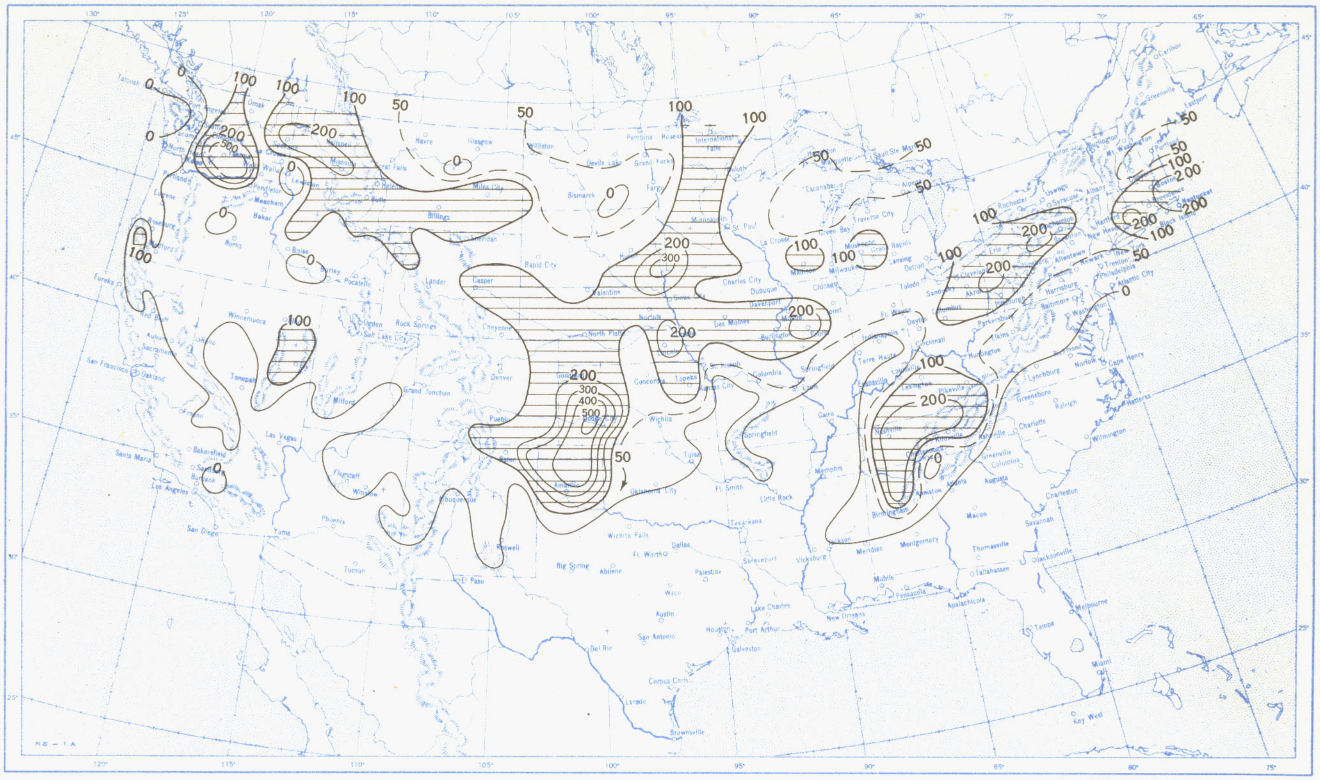
Normal monthly precipitation amounts are computed from the records for 1921-50 for Weather Bureau stations and from records of 25 years or more (mostly 1931-55) for cooperative stations.

Chart IV. Total Snowfall (Inches), March 1957.

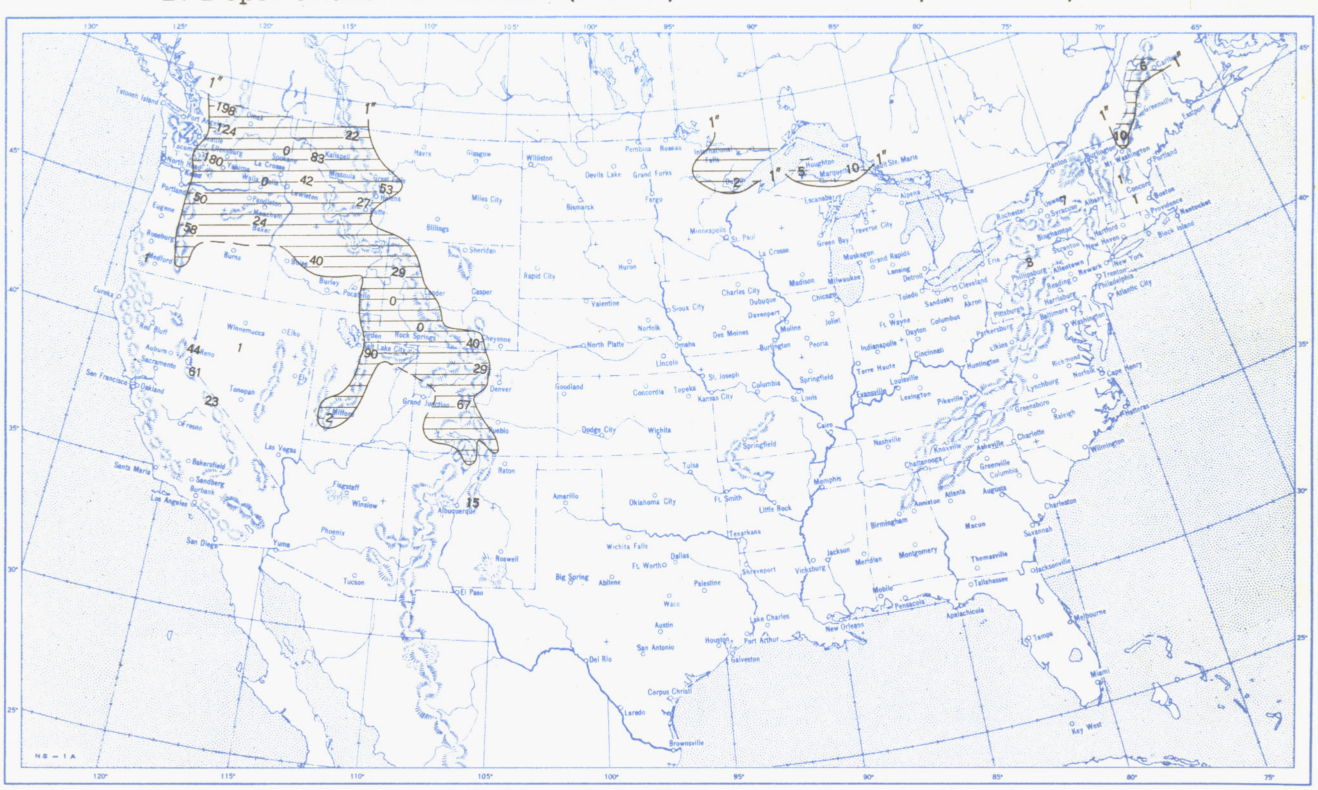


This is the total of unmelted snowfall recorded during the month at Weather Bureau and cooperative stations. This chart and Chart V are published only for the months of November through April although of course there is some snow at higher elevations, particularly in the far West, earlier and later in the year.

Chart V. A. Percentage of Normal Snowfall, March 1957.



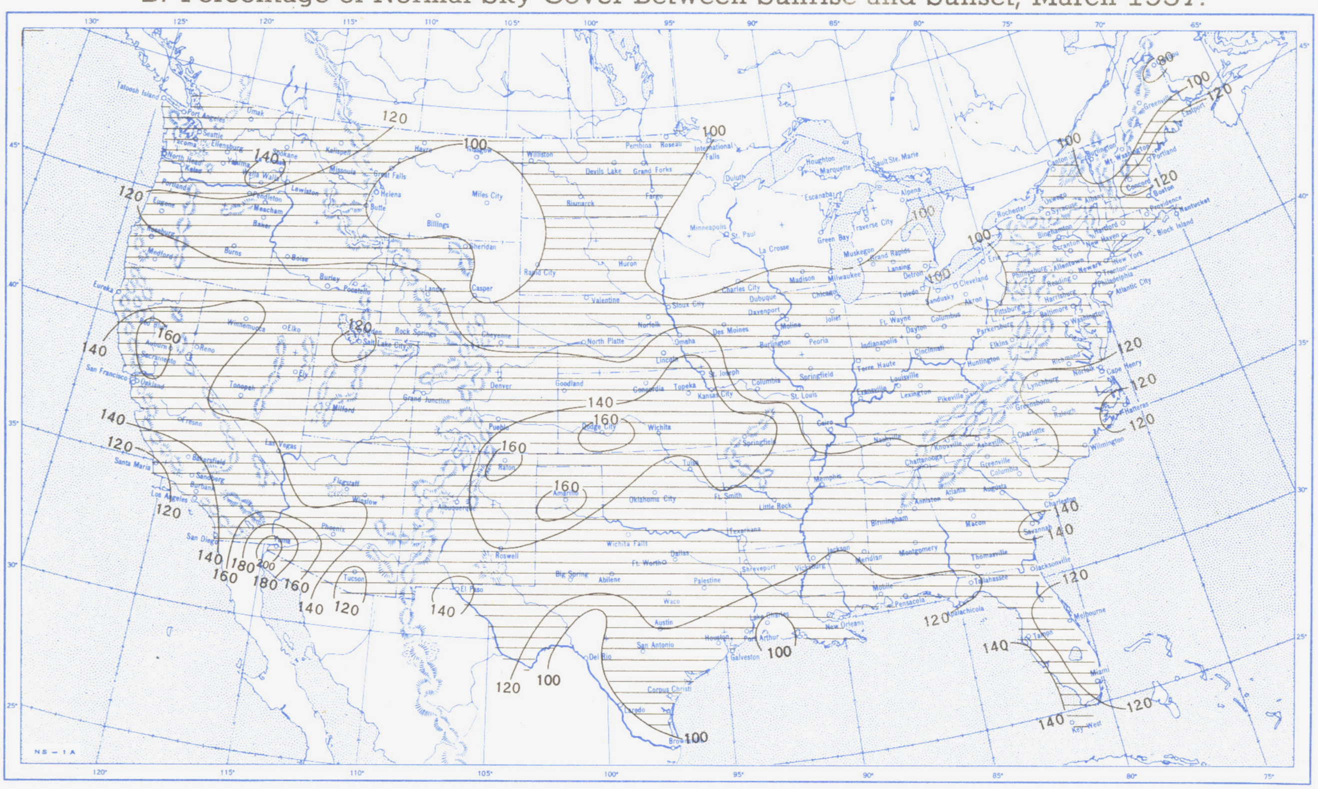
B. Depth of Snow on Ground (Inches). 7:30 a. m. E. S. T., March 25, 1957.



A. Amount of normal monthly snowfall is computed for Weather Bureau stations having at least 10 years of record. B. Shows depth currently on ground at 7:30 a. m. E.S.T., of the Monday nearest the end of the month. It is based on reports from Weather Bureau and cooperative stations. Dashed line shows greatest southern extent of snowcover during month.

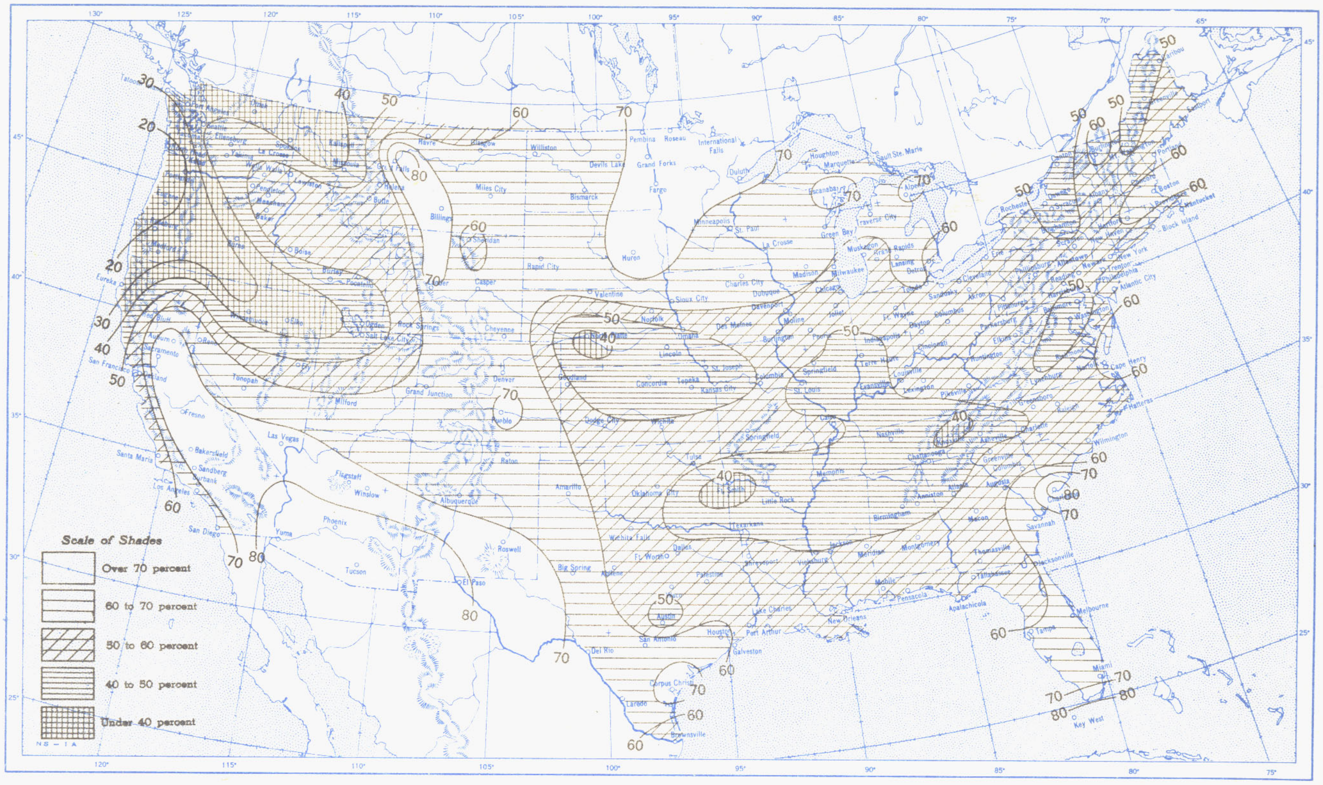
Chart VI. A. Percentage of Sky Cover Between Sunrise and Sunset, March 1957.

B. Percentage of Normal Sky Cover Between Sunrise and Sunset, March 1957.

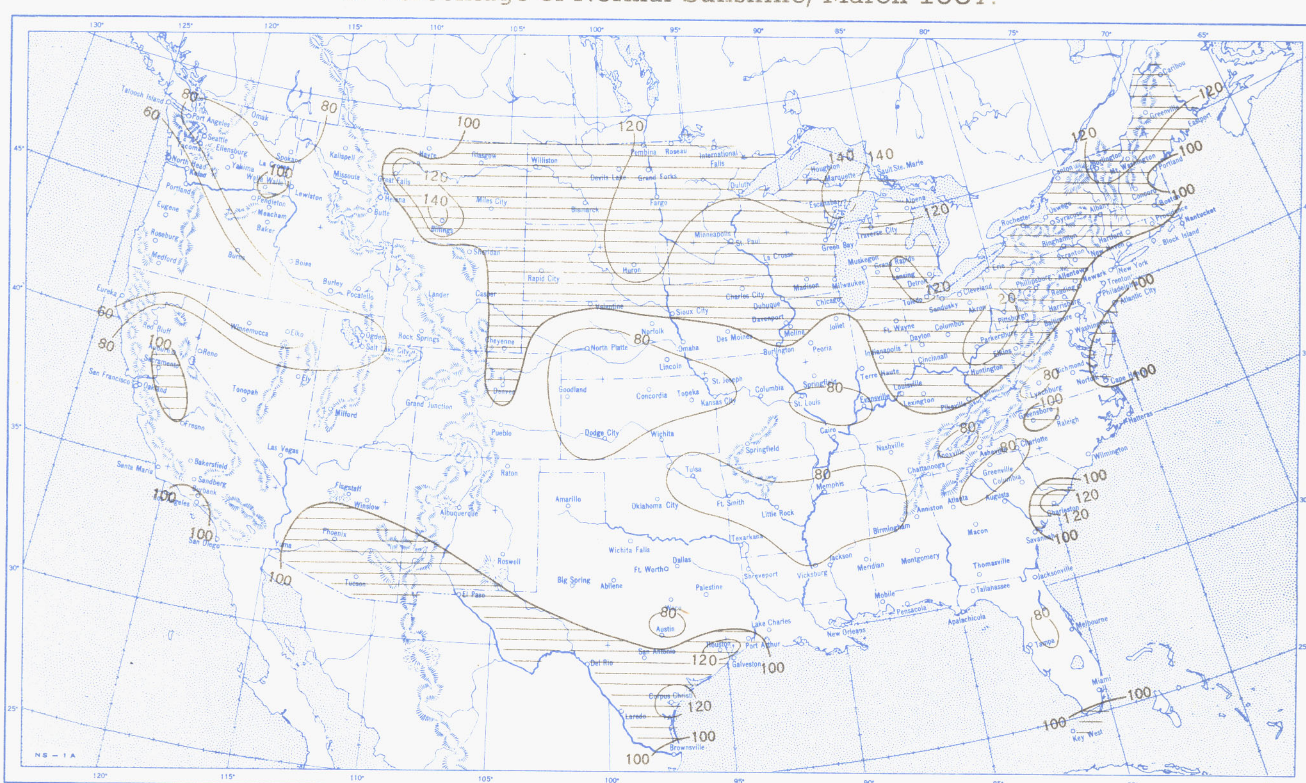


A. In addition to cloudiness, sky cover includes obscuration of the sky by fog, smoke, snow, etc. Chart based on visual observations made hourly at Weather Bureau stations and averaged over the month. B. Computations of normal amount of sky cover are made for stations having at least 10 years of record.

Chart VII. A. Percentage of Possible Sunshine, March 1957.



B. Percentage of Normal Sunshine, March 1957.



A. Computed from total number of hours of observed sunshine in relation to total number of possible hours of sunshine during month. B. Normals are computed for stations having at least 10 years of record.

Chart VIII. Average Daily Values of Solar Radiation, Direct + Diffuse, March 1957. Inset: Percentage of Mean Daily Solar Radiation, March 1957. (Mean based on period 1951-55.)

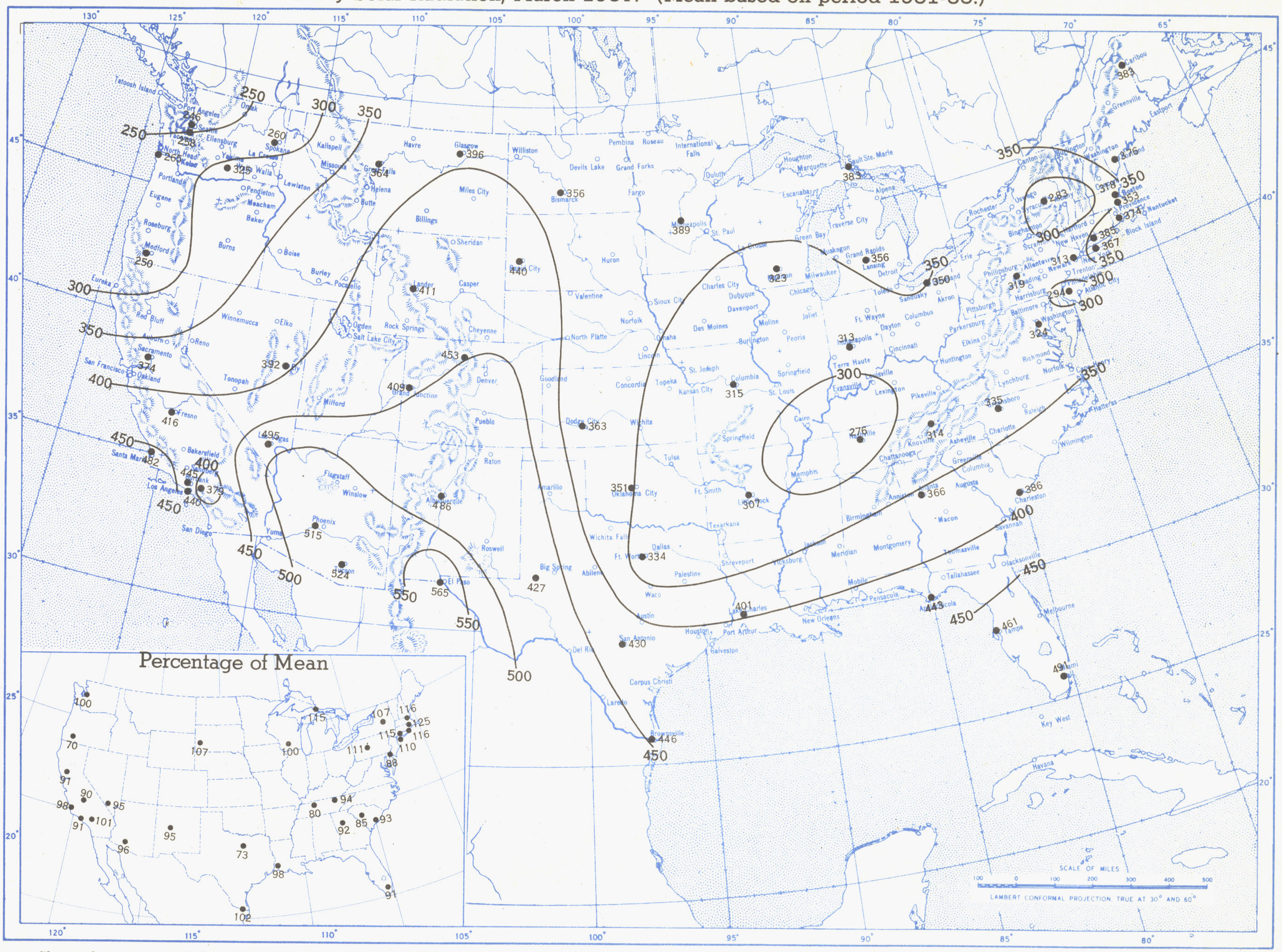
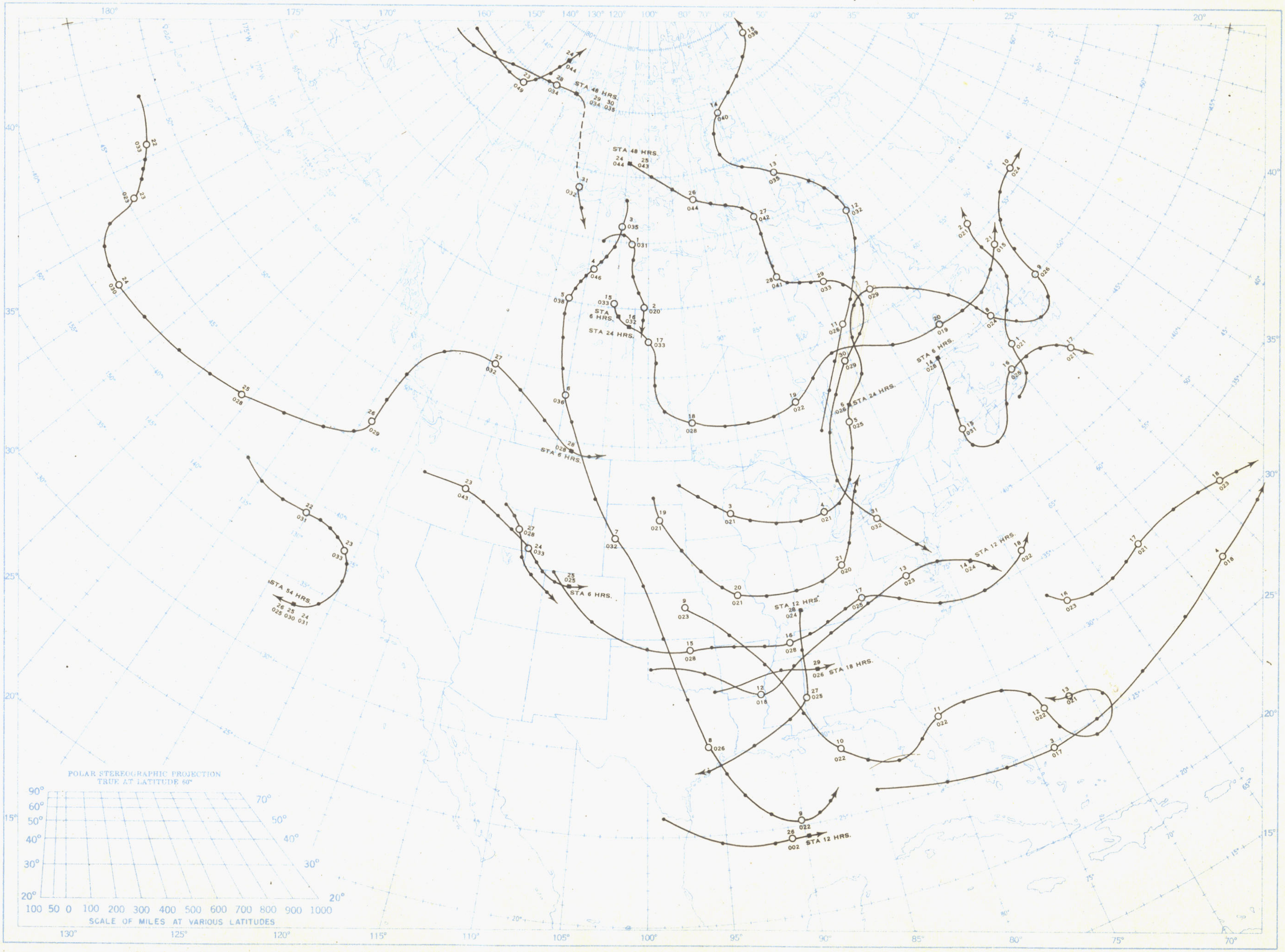


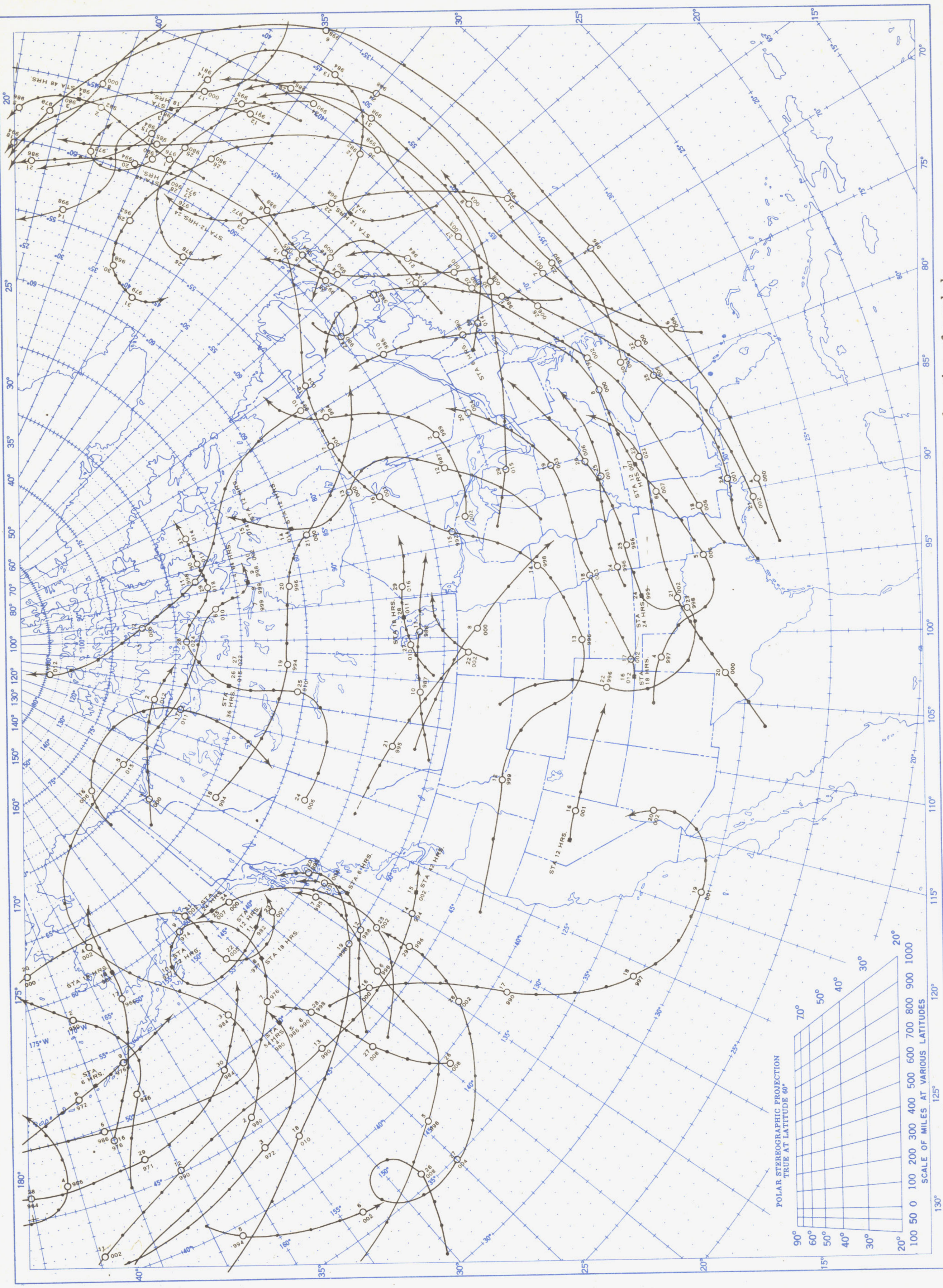
Chart shows mean daily solar radiation, direct + diffuse, received on a horizontal surface in langleys (1 langley = 1 gm. cal. cm. $^{-2}$). Basic data for isolines are shown on chart. Further estimates are obtained from supplementary data for which limits of accuracy are wider than for those data shown. The inset shows the percentage of the mean based on the period 1951-55.

Chart IX. Tracks of Centers of Anticyclones at Sea Level, March 1957.



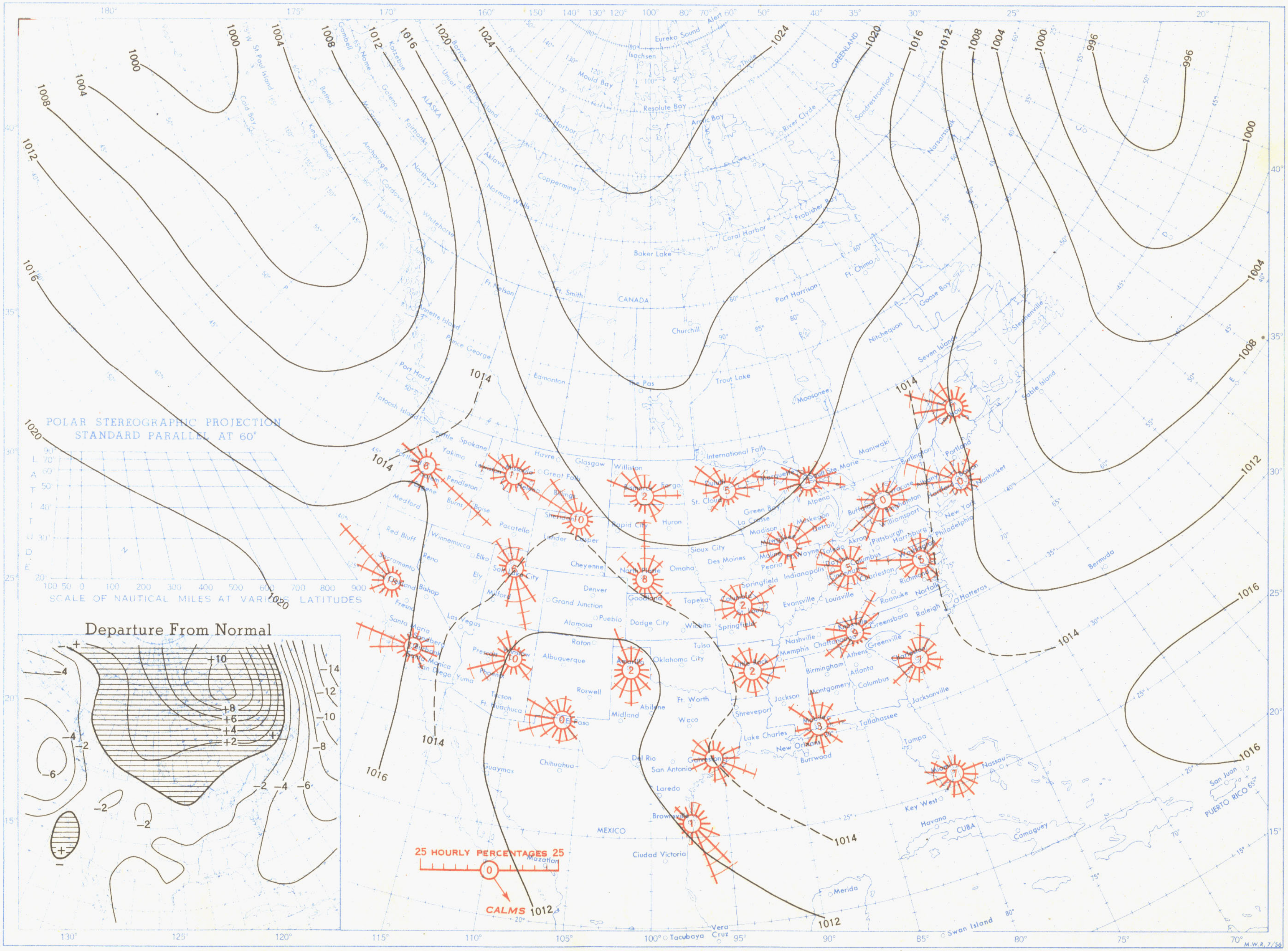
Circle indicates position of center at 7:30 a. m. E. S. T. Figure above circle indicates date, figure below, pressure to nearest millibar. Dots indicate intervening 6-hourly positions. Squares indicate position of stationary center for period shown. Dashed line in track indicates reformation at new position. Only those centers which could be identified for 24 hours or more are included.

Chart X. Tracks of Centers of Cyclones at Sea Level, March 1957.



Circle indicates position of center at 7:30 a. m. E. S. T. See Chart IX for explanation of symbols.

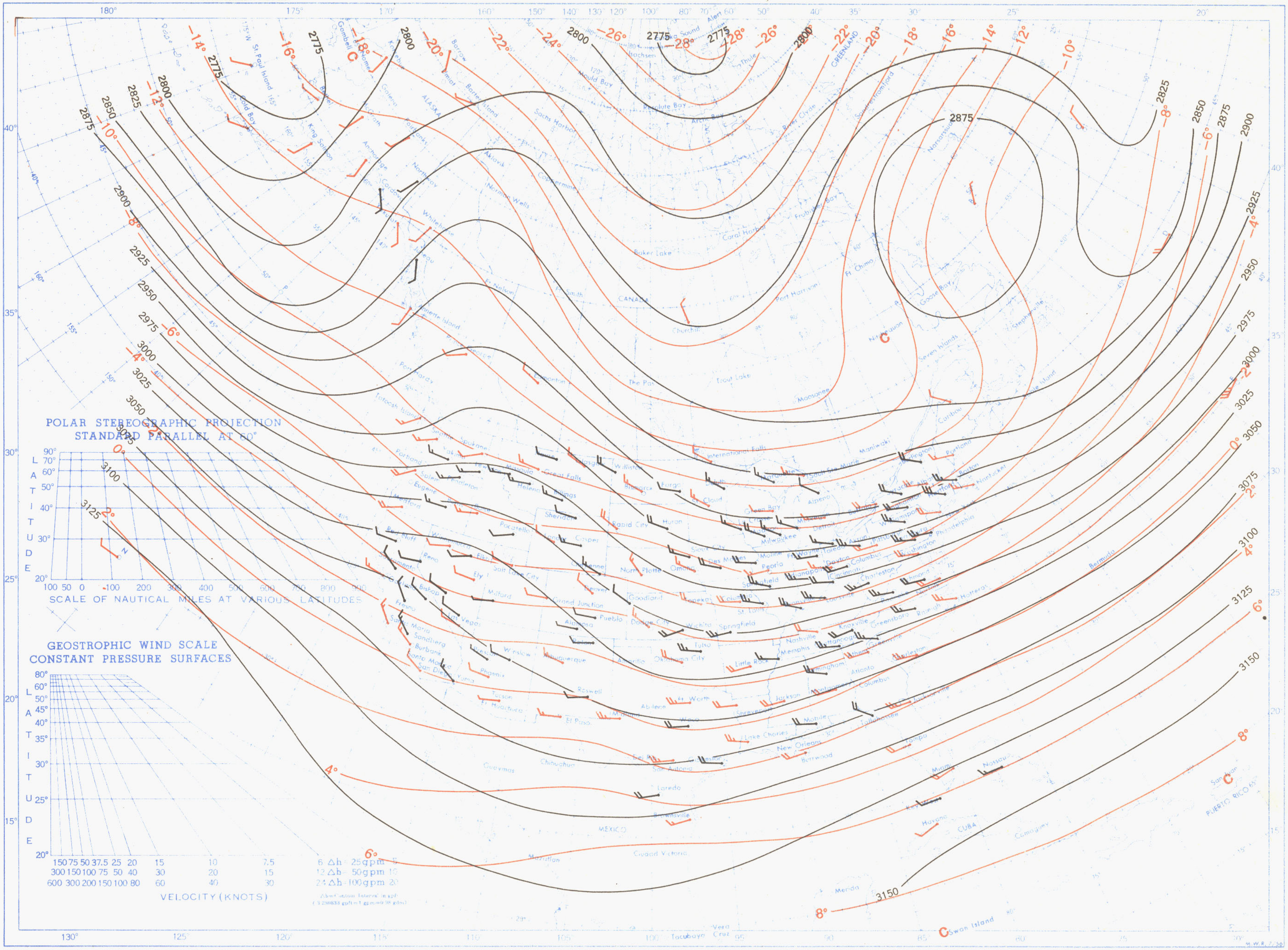
Chart XI. Average Sea Level Pressure (mb.) and Surface Windroses, March 1957. Inset: Departure of Average Pressure (mb.) from Normal, March 1957.



Average sea level pressures are obtained from the averages of the 7:30 a. m. and 7:30 p. m. E. S. T. readings. Windroses show percentage of time wind blew from 16 compass points or was calm during the month. Pressure normals are computed for stations having at least 10 years of record and for 10° intersections in a diamond grid based on readings from the Historical Weather Maps (1899-1939) for the 20 years of most complete data coverage prior to 1940.

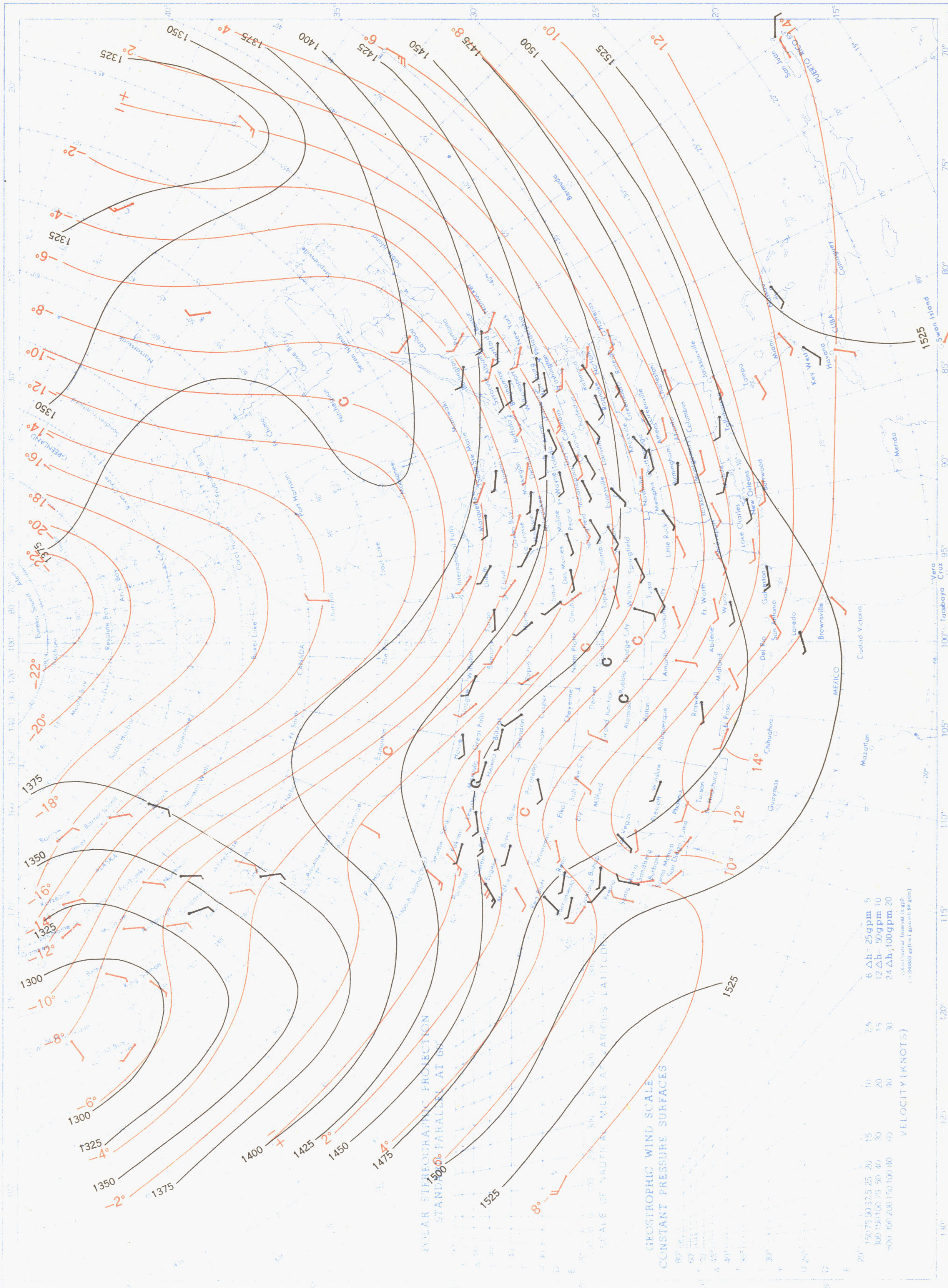
700-mb.

Chart XII. [redacted] Surface, 0300 GMT, March 1957. Average Height and Temperature, and Resultant Winds.



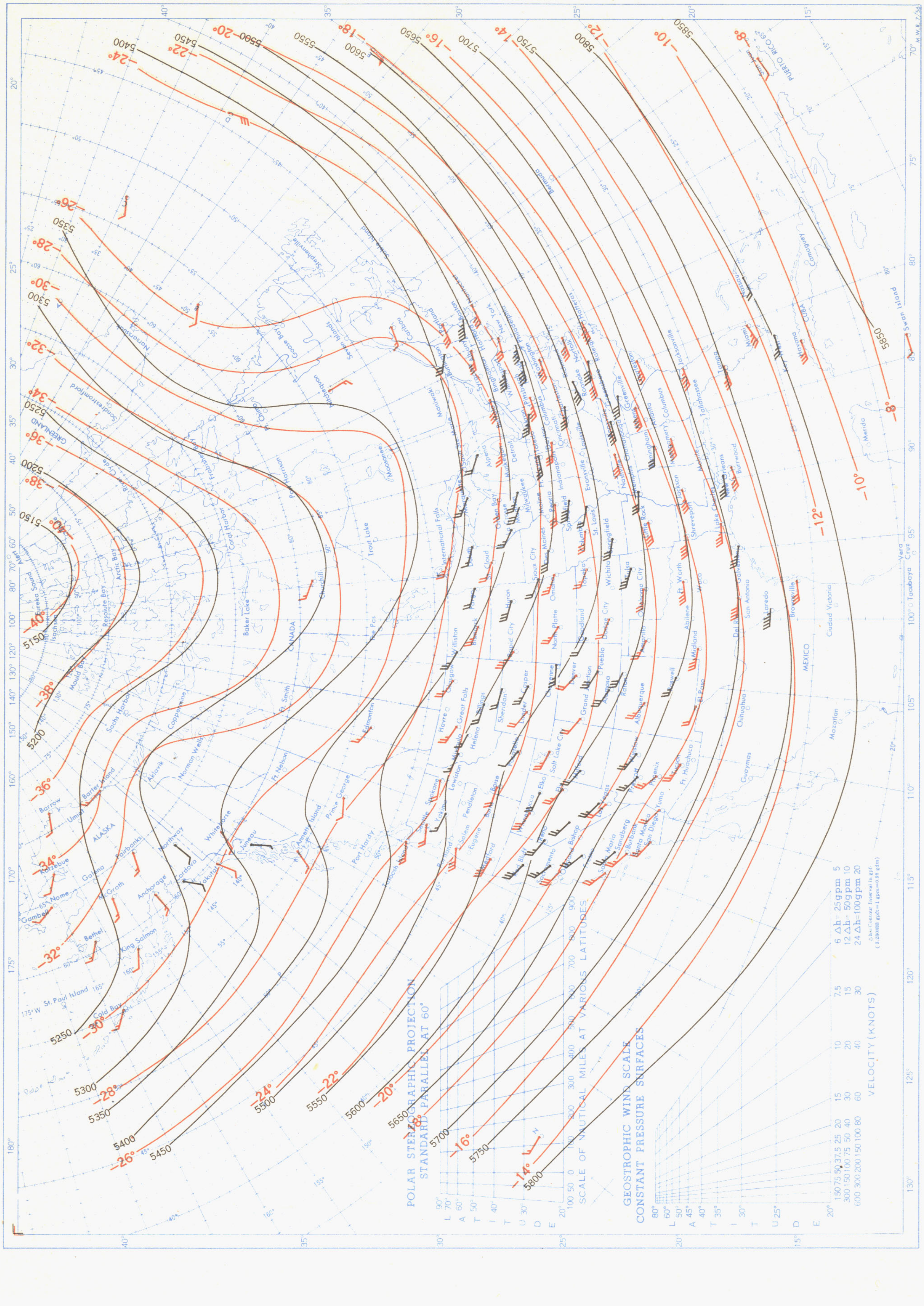
Height in geopotential meters (1 g.p.m. = 0.98 dynamic meters). Temperature in °C. Wind speed in knots; flag represents 50 knots, full feather 10 knots, and half feather 5 knots. Winds shown in red are based on rawins taken at the indicated pressure surface and time. Those in black are based on pibals taken at 2100 GMT and are for the nearest standard height level.

Chart XIII. 850-mb. [redacted] Surface, 0300 GMT, March 1957. Average Height and Temperature, and Resultant Winds.



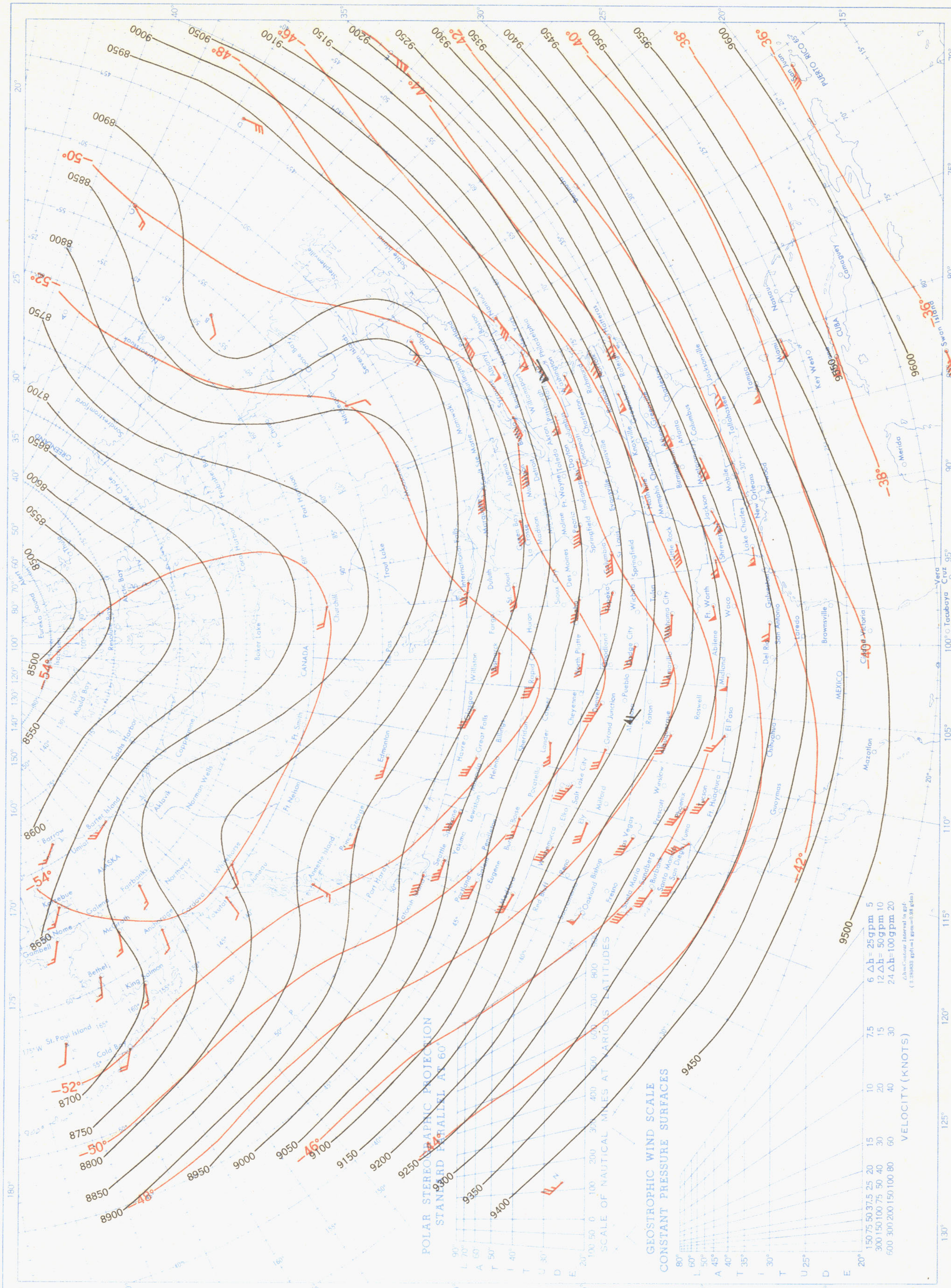
See Chart XII for explanation of map.

Chart XIV. 500-mb. Surface, 0300 GMT, March 1957. Average Height and Temperature, and Resultant Winds.



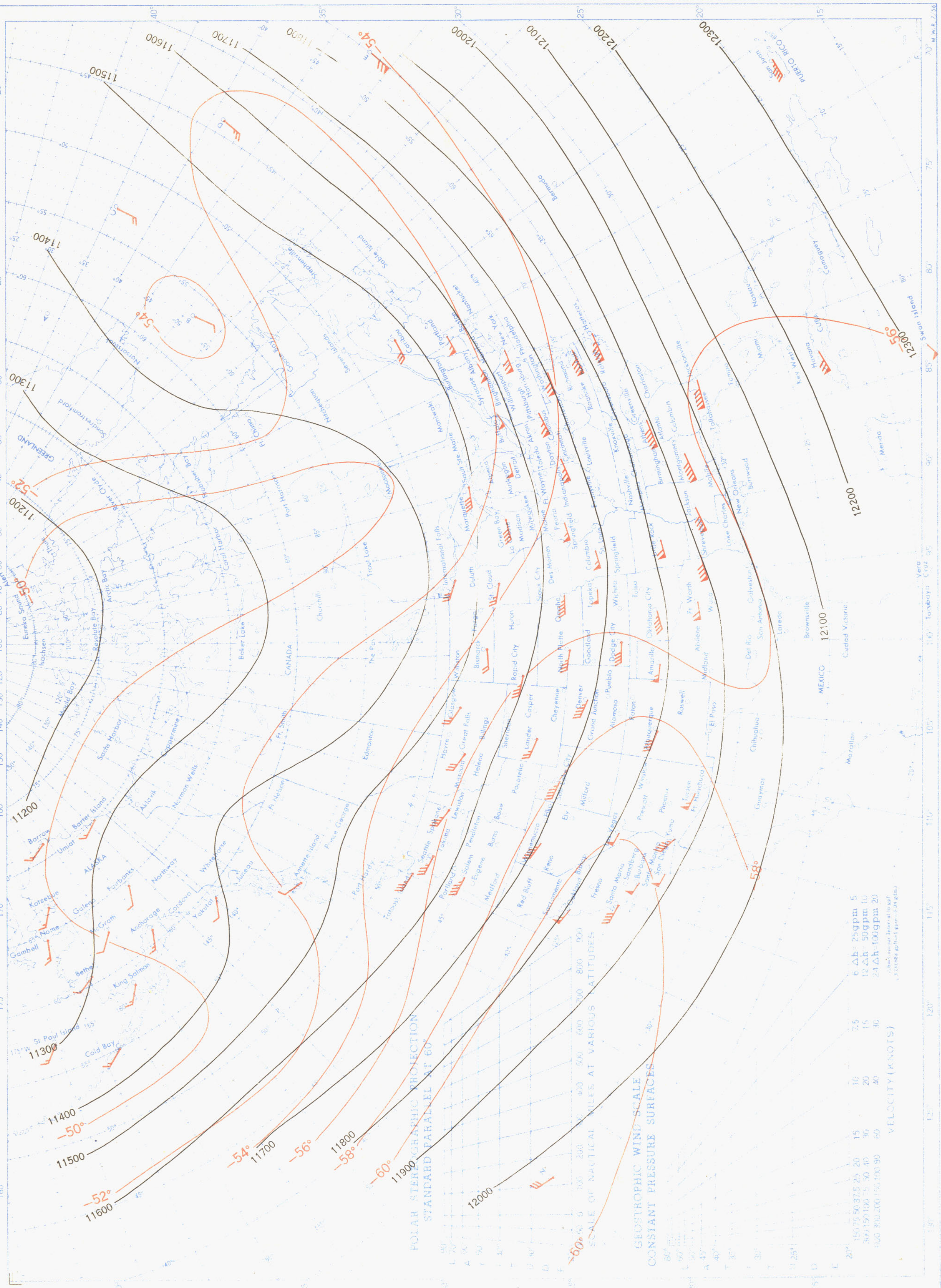
See Chart XII for explanation of map.

Chart XV. 300-mb. Surface, 0300 GMT, March 1957. Average Height and Temperature, and Resultant Winds.



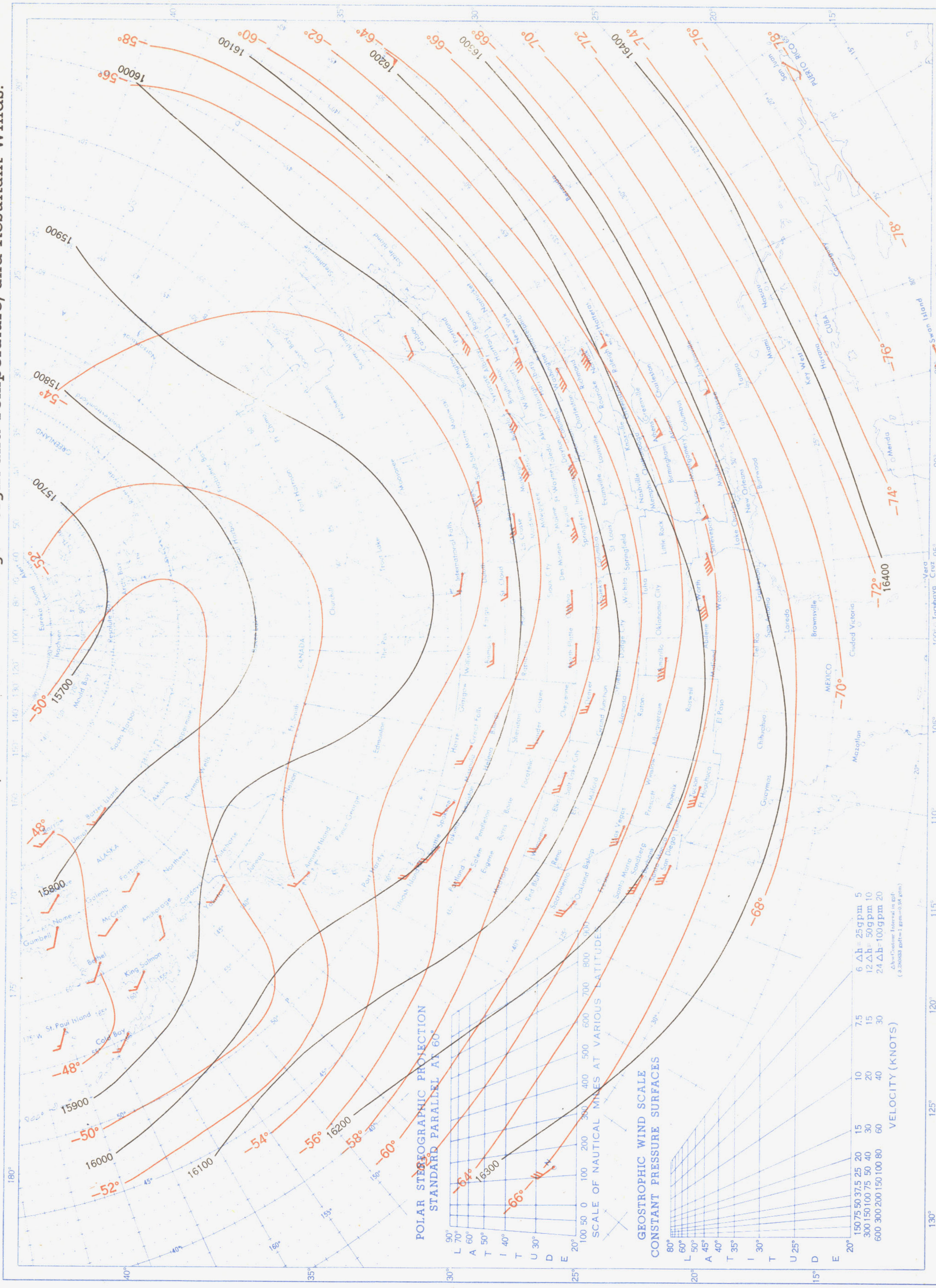
See Chart XII for explanation of map.

Chart XVI. 200-mb. Surface, 0300 GMT, March 1957. Average Height and Temperature, and Resultant Winds.



See Chart XII for explanation of map. All winds are from rawin reports.

Chart XVII. 100-mb. Surface, 0300 GMT, March 1957. Average Height and Temperature, and Resultant Winds.



See Chart XII for explanation of map. All winds are from rawin reports.